Climate Change Adaptation Report

Climate Change Act 2008
Adaptation Reporting Power

Southern Water

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Adapting to Climate Change

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Foreword

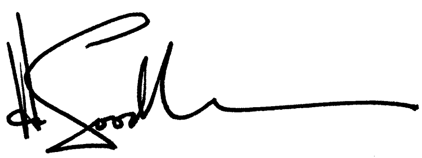
The climate is fundamental to Southern Water's business because we rely on rainfall to provide us with sufficient water to satisfy customer demand but not too intense so as to cause flooding. Any change in rainfall patterns brought about by climate change will affect the service we deliver – and is likely to impact on the cost of delivering that service.

Climate change and its potential impact is, therefore, of great importance to us. However, it is only one of several issues which will affect the company in the future. We face increasing development in the South-East, with the consequent increased demand for water and also increasing urbanisation, which can exacerbate flooding. These changes pose challenges similar and additional to climate change and are very much part of "business as usual".

It is central to water company operations that we are able to understand the challenges for the future, respond to change from any source and maintain an adaptable, resilient and sustainable approach to delivering service to our customers.

We take the threats posed by climate change seriously. We are playing our part in reducing energy use and developing new sources of renewable energy to mitigate the impact of increasing CO2 emissions. We are also seeking to ensure that we understand the potential impact of climate change and the consequences for the business and our customers.

Climate change projections are inevitably uncertain and we will not know, for example, if the recent spate of extreme weather and consequent flooding is triggered by climate change or is part of the normal variability of British weather. If we wait and only take action based on what we can see in the rear view mirror, it will be too late.



Howard Goodbourn
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Southern Water
Adapting to Climate Change

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1. Executive summary (based on Defra cover sheet)

1.1. Information on organisation

Organisation's functions, mission, aims, and objectives affected by the impacts of climate change. A summary of your organisational purpose and key strategic priorities which are or will be affected by climate change is important when identifying risks to your organisation.

Southern Water Services (SWS) provides water services to over 2 million customers and wastewater services to over 4 million customers in Kent, East and West Sussex, Hampshire and the Isle of Wight. It is a major water and sewerage infrastructure provider.

The principal activities of the company are:

- Water resources
- Water treatment
- Water distribution
- Wastewater collection and surface water management
- Wastewater treatment
- Sludge treatment and disposal

All of these activities are likely to be affected by climate change, whether directly or indirectly, by temperature increase, changing rainfall patterns, more extreme weather or sea-level rise.

1.2. Business preparedness before Direction to report was issued

Has your organisation previously assessed the risks from climate change?

Have you a baseline assessment of the risks of climate change to your business currently? The requirements of the Direction can build upon any existing risk assessment you have in place. Please include a summary of findings from your previous risk assessment(s) in your report.

If so, how were these risks and any mitigating action incorporated into the operation of your organisation? It is useful to understand whether, and to what extent climate change risks are already incorporated into your business risk management processes at the strategic level.

We have been aware of the risks posed by climate change for many years, and were involved for example in the early UK Water Industry Research (UKWIR) into the impact of changing rainfall patterns on flood risk 'Climate Change and the Hydraulic Design of Sewerage Systems' published in 2003. The impact of climate change on water resources has long been recognised and forms a key part of our Water Resource Management Plan.

The major risks posed by climate change are:

- Flooding, either customer properties, or water company assets
- Stress on water supply, from either increased demand or reduced supply

A more detailed analysis of the risks posed is presented in Appendices 2, 3, and 4 and discussed in the body of the report. It is important to recognise that, in general, the risks posed by climate change are no different from other pressures (growth and new development, environmental stress, existing flooding for example) which are central to the company's business. The scale of threat may be different, but there are few new threats.

The impact of flooding is to a limited extent being dealt with through an allowance for rainfall uplift in sewer design for new flood alleviation projects. However, this will have relatively minor effect, particularly on major events (typically those less than 2% probability in any year). In this respect the Flood and Water Management Act is a significant piece of legislation in bringing together all flood risk authorities to work together to understand and mitigate the impacts of severe flooding.

Risk to the supply demand balance for water is fully dealt with in the Water Resource Management Plan.

1.3. Identifying risks due to the impacts of climate change

What evidence, methods, expertise and level of investment have been used when investigating the potential impacts of climate change? What evidence have you assimilated to inform your risk assessment? What has been your approach (quantitative, qualitative, scenario based)? What resource (£ / person / days) have been assigned to this assessment? Briefly summarise your approach – in house staff, professional advisors, research expertise?

The evidence used in this report has been gathered from several sources:

- UKCP09, and prior to that UKCIP02 and 98
- Research carried out by independent consultants, managed by UKWIR
- In-house expertise developed through workshops and seminars (Met Office, UKCIP etc), involvement in the WaterUK Climate Change Focus Group
- Study of the data provided by UKCIP

The level of investment is difficult to quantify, because information gathered for this report is to large extent part of business as usual, and costs are not easily separated out. The gathering of information and preparation of the report itself represents 20-30 man-days effort.

1.4. Assessing risks

How does your organisation quantify the impact and likelihood of risks occurring? Provide here a brief summary of the methodological approach to quantification where this has been possible and your categorisation of likelihood and impact. State what criteria you have used to characterise the significance of the risks (high, medium, low, negligible) and how these have been derived. What level of confidence do you have in the analysis?

Southern Water's responsibilities cover a wide geographical area, and a broad spectrum of activities, all affected in some way by climate change. Sufficient data exists to be reasonably confident about the general direction of climate change, but quantification of the risk has necessarily to be done at a localised scale rather than across the business as a whole.

Quantification of risk to the supply demand balance is carried out through the mechanism of the Water Resource Management Plan; quantification of flood risk is carried out through drainage area plans. For water distribution, computer models are regularly updated to give projections of low pressure; and wastewater treatment works performance is continually tracked. Growth and new development for water and wastewater services is revised for each price review period.

All of these mechanisms include the impacts of climate change, and feed into the five-yearly business plans required by Ofwat. Quantification of risk has therefore not been covered within the current report.

The criteria used to assess risk are set out in section 4:

- Severity – consequences for customers (level of service) or for company (resources, either human or financial)
- Immediacy – how soon the effects may be felt, and whether the onset is likely to be gradual and progressive, or sudden
- Inertia – time required to respond to impact;
- Barriers to response – what legislative or regulatory barriers prevent response
- Business as usual – whether the potential effects of climate change are already embedded in company business

1.5. Uncertainties and assumptions

What uncertainties have been identified in evaluating the risks due to climate change? Where are the key uncertainties in the analysis of the impacts of climate change and what impact do these have on the prioritisation of adaptation responses and risks for your organisation? How have these uncertainties been quantified and, in brief, what are the implications for the action plan?

What assumptions have been made? The key strategic business assumptions and methodological assumptions that underpin your analysis of impacts, action plan and analysis of the risks. Well-evidenced and justified assumptions are important to the credibility of and confidence in the risk assessment.

The general direction of climate change for the south-east is reasonably well-established, and has not changed significantly from the UKCIP98 and UKCIP02 predictions. However, the probabilistic nature of the UKCP09 projections clearly illustrates the uncertainties around quantification of change. Figure 8 in Appendix 1 (medium scenario projections for mean summer precipitation) shows a decline in summer rainfall of about 22% to 2099 for the 50%ile medium emissions scenario. Figures 7 and 9 (low and high scenarios) show about 15% and 30% decline for the 50%ile value. The wider extremes of prediction show a variation of about 5% reduction (67%ile low emissions) to 40% (33%ile high emissions scenario).

Dealing with uncertainties of this nature necessitates a process of continually revised action plans, so that proposals can be periodically revisited and revised to take account of updated climate change projections. It has to be recognised also that climate change is one of many uncertainties which face the water industry. The water industry has to be flexible and adaptable to meet all uncertainties across all aspects of the business.

Long term plans therefore need to take account of all threats and opportunities, of which climate change is one. The Water Resource Management Plan is a good example of such a long term plan. Drainage Area Plans deliver similar benefits for drainage, and the implementation of the Flood Risk Regulations will enable all flood risk authorities to work together to develop flood risk management strategies on a rolling six year cycle.

1.6. Addressing current and future risks due to climate change – summary (one line is required per risk)

See appendix 4.

1.7. Barriers to implementing adaptation programme

What are the main barriers to implementing adaptive action? What do you see as the key challenges to implementation of your action plan? How will these be resourced and addressed? Briefly, what additional work is required?

Has the process of doing this assessment helped you identify any barriers to adaptation that do not lie under your control? Interdependencies may arise where others' actions are likely to impact on your ability to manage your own climate change risks. Briefly comment on where this is the case.

There are two significant barriers to adaptation which are to an extent beyond the means of water companies to resolve alone.

The first is cost. Water companies are entirely funded through water charges, and are subject customer and political pressure to restrict rises to charges.

The second barrier is the conflict between adaptation measures (for example improvements to wastewater treatment standards to maintain environmental quality) which will lead to an increase in energy consumption, and hence exacerbate climate change. A compromise must therefore be found which will enable the environment to be protected without contributing to further climate change.

In addition to these barriers, it is conceivable that, with sea level rise and changing rainfall patterns, some communities may not be sustainable. Flooding from sea level rise and extreme rainfall are not the responsibility of water companies, but it is likely that the first signs of this type of flooding will show through the failure of the water company sewerage systems which will be overwhelmed by groundwater and surface water, as land drainage systems progressively fail. There are signs that this is already occurring in low-lying coastal areas in the south-east.

1.8. Report and review

How will the outcome of the adaptation programme be monitored and evaluated and what is the timetable for this? Adaptation programmes are expected to reduce the residual risk to organisations from climate change. What measures will you put in place to monitor this?

How do you propose to monitor the thresholds above which impacts will pose a threat to your organisation (including the likelihood of these thresholds being exceeded and the scale of the potential impact)? It is possible that the current risk appetite within your organisation will change on account of the climate change risks identified. How will this be monitored?

How will the benefits of the programme be realised and how will this feed into the next risk assessment and options appraisal? Briefly state your plans for the next iteration of your climate change risk assessment.

How have you incorporated flexibility into your approach? State whether your approach leaves you open to exploring different pathways in future or whether any of the measures have locked the approach into one particular path, with justification

As described in the body of the report, there are few new risks posed by climate change that are not already built into our day-to-day approach to manage change arising for other reasons.

Water companies are required to be flexible and adaptable to meet the challenges of balancing supply and demand, and meeting changing environmental standards. The periodic price review process is the principle vehicle for considering all challenges and opportunities. The annual reporting requirements to the various regulators (Ofwat, DWI, EA etc) provide a platform for assessing trends on an annual basis and feed into the investment requirements at each price review.

1.9. Recognising opportunities

What opportunities due to the effects of climate change and which the organisation can exploit have been identified?

The risk assessment is also expected to generate opportunities for organisations, have these been captured? What are the key ones and the expected net benefits?

Climate change presents major challenges to all aspects of water company work. No significant benefits have been identified.

1.10. Further comments / information

Do you have any further information or comments which would inform Defra (e.g. feedback on the process, the statutory guidance, evidence availability, issues when implementing adaptation programmes, challenges, etc)?

There are two key aspects of climate change which are not well understood. They are:

- Likelihood of severe drought - rainfall shortfall over a two=three year span
- Likelihood of increased incidence of extreme high-intensity short duration (sub-daily) rainfall.

These two aspects are of considerable importance to the water industry in understanding the threat to water resources, and the frequency of severe flooding.

Flooding is a complex issue, involving many different agencies (Water Companies, Environment Agency, Local Authorities and landowners). The Flood and Water Management Act has the potential to remove a number of obstacles, with much clearer definition of responsibilities for each of the agencies involved, and also the requirements for Sustainable Drainage Systems (SuDS) for new development. This report assumes that the Act will be implemented in full and that the various responsible agencies will be adequately funded and will fulfil their obligations.

The interdependencies between the water company activities, and the power, telecoms and transport sectors is a major component in delivering the water service. It is key that these sectors also respond to the challenges posed by climate change.

2. Introduction

Two recent reports (National Infrastructure Plan – HM Treasury; and Adapting to Climate Change in the Infrastructure Sectors - PricewaterhouseCoopers LLP) highlight the importance of critical national infrastructure and the potential risks posed by climate change.

The National Infrastructure Plan highlights the following:

- Climate change is a key issue in long-term planning for critical infrastructure, but is not the only challenge for the future. Obsolescence of existing infrastructure, and demand growth are also major issues.
- The interdependencies between the infrastructure providers, and the need to understand the risks and opportunities which this presents.
- The role of economic regulators in promoting climate change adaptation. The government is proposing a review of the roles and functions of Ofwat.

The PwC report focuses on the particular threats posed by climate change to critical national infrastructure, with reference to:

- Information gaps and managing uncertainties
- Balancing priorities – relatively low priority when set against other more immediate risks
- Short-term regulatory focus – principally on statutory duties, levels of service, and short-term value for money, climate change uncertainties
- Private sector priorities – competing demands of short term profit vs long-term investment at Board level and for Shareholders
- Interdependencies – the relatively lower level of understanding of the additional risks resulting from the interdependencies between critical utility providers

Water companies, in comparison with other industries, have relatively little control over demand, either water supply, or wastewater disposal. Water usage is driven by growth and new development, and water resources are influenced by long-term (annual) rainfall variability. Wastewater and surface water collection and treatment is similarly affected by growth and new development, and subject to short-term (sub-daily) rainfall patterns. Drinking water quality is subject to UK and EU legislation, and governed by Drinking Water Inspectorate (DWI) as regulator. Wastewater quality and sludge recycling are similarly subject to UK and EU legislation, and government principally by Environment Agency as regulator.

The water industry thus has to deal with many uncertainties outside its control, and must necessarily be flexible and adaptive in dealing with each new challenge, from whichever source. There are few completely new risks posed by climate change although some risks may increase, because of either increased probability, or increased severity. To that extent, planning for adaptability is already part of 'business-as-usual' for water and sewerage companies.

The effects of climate change are very wide ranging, affecting all aspects of the company's operations. However, at a higher level (eg water resource planning, or changes in environmental standards) the impact of climate change can be seen as just one element of the need for water and sewerage companies to become increasingly flexible and adaptable to many challenges which may arise in the future.

For the purposes of this report, climate change risk has been considered in terms of:

- Severity - consequences for customers (level of service) or for company (resources, either human or financial)
- Immediacy – how soon the effects may be felt, and whether the onset is likely to be gradual and progressive, or sudden
- Inertia – time required to respond to impact
- Barriers to response – what legislative or regulatory barriers prevent response
- Business as usual – whether consideration of the effects of climate change is already embedded in company business

The principal impacts are from changes in rainfall patterns (both seasonal/annual and sub-daily), and from sea-level rise. Changes in seasonal and annual rainfall patterns could have a major impact on water resource, whilst changes in daily and sub-daily rainfall patterns could give rise to increased flooding of company assets, affecting the ability to deliver a service, or direct flooding of customer's property.

The threat of long-term rainfall shortfall affecting water resource is ever-present, and is dealt with in the company Water Resource Management Plan. The impact can be seen as severe, medium-term (slow onset), significant inertia, with regulatory barriers (in terms of providing evidence of need), but equally part of business as usual. There are also gaps in knowledge: the UKCP09 projections do not deal with the likelihood of extended periods of drought.

The threat posed by extreme daily/sub-daily rainfall causing flooding is also ever present, and is considered as part of the drainage area planning process, and the maintenance of the DG5 registers. As with drought, the impact can be seen as severe, immediate, significant inertia, with regulatory barriers (in terms of delivering cost beneficial schemes), but equally part of business as usual. There are also gaps in knowledge: cyclonic rainfall is not well understood or easily modelled, and hence the UKCP09 projections do not provide sufficient data. In addition, responsibility for flooding is highly complex, being split between a number of private and public agencies, as well as private landowners. The Flood and Water Management Act has the potential to remove a number of obstacles, with much clearer definition of responsibilities for each of the agencies involved, and also the requirements for Sustainable Drainage Systems (SuDS) for new development.

Sea-level rise will affect both water resource availability (through the risk of saline infiltration into coastal boreholes), and the risk of flooding, whether direct tidal flooding, or resulting from higher groundwater levels. Sea-level rise is more easily predictable, at least for the next 30-50 years. It can be characterised as severe (in coastal areas), slow-onset, with significant inertia, and barriers to implementation, principally cost.

The water sector has long been aware of the risks posed by climate change, and has promoted research on the subject since the mid 90's, covering all aspects of water company activities.

Major events can often trigger significant changes in societal behaviour. The 2007 floods and the subsequent report by Lord Pitt served to highlight the effects of extreme weather, and the risks posed by changes in weather patterns and the possible association with climate change. Lord Pitt's reports concluded with 107 recommendations, of which over 40 had some relevance for the water industry. WaterUK subsequently set up a Flood Implementation Group which examined the Pitt recommendations, plus recommendations from other reports relating to the 2007 floods. The Flood Implementation Group produced a further set of 18 recommendations specifically for the water industry together with a final report on progress against these actions (One Year On - Report of the Water UK Flooding Implementation Group - Lessons learned from the floods of summer 2007 – July 2009).

In addition to work on adaptation measures, Southern Water is also implementing a range of initiatives during AMP5 to reduce energy consumption and CO2 emissions to mitigate climate change.

We have made significant investment in biogas fuelled CHP and now have 13 operational units with the capacity to generate over 10% of our power demand. Opportunities for wind and solar energy are also being explored.

We are also making significant investment in improving management information on energy consumption. We are planning to install enhanced consumption monitoring at our top 20 power consuming sites to provide greater granularity on the process and individual asset consumption. We are also installing 2,000 smart meters at our smaller sites to provide accurate and timely consumption data.

Improved energy efficiency is also a key focus and we have a range of initiatives including improved pump and blower efficiency monitoring, advanced aeration control and energy recovery through the installation of hydro turbines in outfall pipes.

3. Background

3.1. Company business

Southern Water Services (SWS) provides water services to over 2 million customers and wastewater services to over 4 million customers in Kent, East and West Sussex, Hampshire and the Isle of Wight. It is a major water and sewerage infrastructure provider.

The principal activities of the company are:

- Water resources
- Water treatment
- Water distribution
- Wastewater collection and surface water management
- Wastewater treatment
- Sludge treatment and recycling
- General activities supporting the key business functions

3.2. Water resources, treatment and distribution

The Southern Water area of supply is complex in nature due to the fragmented geographical areas of supply and the inter-connections between its own supply areas as well as those with a number of other water companies. The area supplied by Southern Water covers a total of some 4,450 sq. kms, and extends from East Kent in the east, through parts of Sussex, to Hampshire and the Isle of Wight in the west. The total number of customers served is 2.26 million, with water supplied to 619,000 unmeasured properties (households and non-households) and 388,000 measured properties.

Water is supplied from 117 sources, and treated at 99 water treatment works. The water is distributed via 13500km of main and 237 service reservoirs. The average water into supply in 2009 was 560Ml/d. As a result of demand management policies and leakage reduction, the water into supply has fallen significantly since privatisation, from a figure of 730 Ml/d in 1989.

The geographically separate supply areas, known as Water Resource Zones (WRZs), supplied by Southern Water, and also the geographical relationship with other water companies in the region, are shown in Figure 3.1.

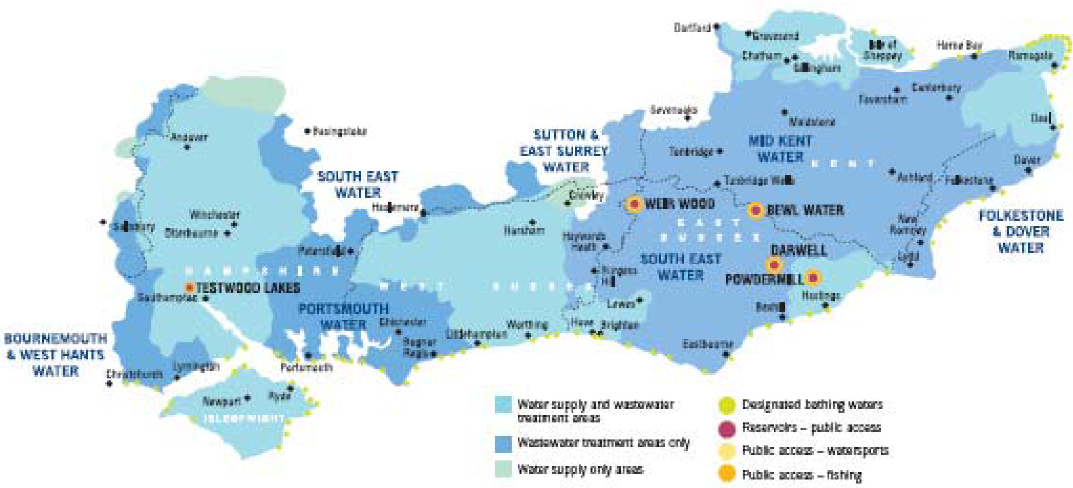

Figure 3.1 Southern Water's Current Area of Supply

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Water resources planning takes place at the level of the Water Resource Zone (WRZ) which is the largest area in which all customers bear the same risk of restrictions during drought. There are ten WRZs in the Southern Water area, some of which are connected by means of treated or raw water transfers. The spatial basis for water resources planning within the Southern Water supply area is as follows:

Western sub-regional area (Western area), which includes the following WRZs:
- Isle of Wight WRZ;
- Hampshire South WRZ;
- Hampshire Andover WRZ; and
- Hampshire Kingsclere WRZ.

Central sub-regional area (Central area), which includes the following WRZs:
- Sussex North WRZ;
- Sussex Worthing WRZ; and
- Sussex Brighton WRZ.

Eastern sub-regional area (Eastern area), which includes the following WRZs:
- Kent Medway WRZ;
- Kent Thanet WRZ; and
- Sussex Hastings WRZ.

Southern Water also has boundaries with seven other water companies. These are:
- Bournemouth and West Hampshire Water;
- Wessex Water;
- Portsmouth Water;
- Thames Water;
- Sutton and East Surrey Water;
- South East Water, which includes the area of the former Mid Kent Water, and
- Veolia South East, formerly Folkestone and Dover Water Services.

There are a several bulk supplies between the companies.

The majority (68%) of Southern Water's supplies comes from groundwater, predominantly from the chalk aquifer which is widespread across the region. A further 28% comes from river abstractions: most notably the Eastern Yar on the Isle of Wight; the Test and Itchen in Hampshire; the Western Rother in West Sussex; the Eastern Rother in East Sussex; and the Medway and Stour in Kent. The remaining 4% of supplies come from the surface water impounding reservoirs, all of which are owned and operated by the company. The largest of these is Bewl Water. This is a pumped storage reservoir, with water being abstracted from the River Medway, stored and subsequently released as required for re-abstraction further downstream. The reservoir is owned and operated by Southern Water, but South East Water has an entitlement to 25% of the scheme yield.

The other three reservoirs in the Southern Water supply area are Darwell, Powdermill and Weir Wood. Darwell and Powdermill are used to supply the Sussex Hastings WRZ, with Darwell also providing a bulk supply of water to South East Water. Weir Wood, in north Sussex, supplies parts of Crawley and Horsham and also provides bulk supplies to South East Water.

It is winter rainfall that determines the status of sources and hence the ability to abstract water from them. Southern Water is situated in one of the driest regions in the country. Total annual rainfall averages about 730 mm. a year. However, it is the rainfall during the autumn and winter periods that is critical to the availability of water resources in the region. It is only during this period that rainfall can infiltrate through the soil to recharge groundwater reserves, store river baseflow for the following year and replenish surface water storage.

3.3. Wastewater collection and treatment

Southern Water supplies wastewater services to the whole of East and West Sussex, and the Isle of Wight, and the majority of Hampshire and Kent, as well as small areas in Surrey. The total population served is 4.2M, and the area covered is 10550km2.

The area is characterised by the long length of coastline (1250km) and the fact that the majority of the large centres of population are sited on the coast. A number of coastal areas are extremely low-lying, close to, or below mean high water spring tide. The largest of these areas is Portsea Island (Portsmouth). There are other smaller settlements at or near sea-level, particularly in West Sussex, in the coastal areas of Arun and Chichester District Councils.

The underling geology is significant in terms of flood risk, and varies from impermeable clays in the Weald, which can lead to flash flooding during intense rainfall, and chalk downland, which can give rise to high groundwater levels and consequent flooding during long periods of continuous rainfall.

The area is served by 371 discrete catchment areas (sewer networks and treatment works). There is no connectivity between these catchments. The total length of sewer (foul, combined and surface water) in these catchments is approximately 21600km, and includes 2300 pumping stations.

The transfer of private sewers and laterals to the water companies in October 2011 is expected to add a further 15-17500km of sewer and lateral, and up to 1000 additional pumping stations.

Of the 371 works, 281 discharge to water courses, 24 discharge to ground, and the remainder to coastal or estuarine waters. Many of the major treatment works discharge to significant water courses:

- Rivers Medina and Yar on the Isle of Wight
- Test and Itchen in Hampshire
- Arun, Adur and Ouse in Sussex
- Medway and tributaries in Kent.

Most of the major coastal towns and cities are served by coastal works which discharge direct to the marine environment. Nineteen discharge to coastal waters, and a further 47 to estuarine waters. Twenty-nine of the works are served by long sea outfalls.

3.4. Sludge Treatment

Southern Water currently treats in excess of 100,000 tds (tonnes dry solids) of sludge per year and operates 18 sludge treatment centres (STC's) all utilising anaerobic digestion as the treatment process. At five of these sites we also operate thermal drying. We anticipate the volume of sludge to increase by about 10% over the next 5 year period. The sites range in treatment capacity from 750 – 20,000 tds/year. The majority of the treatment centres have been constructed or significantly refurbished/enhanced over the last 10-15 years.

The Company's original sludge strategy was developed in the mid-1990's, and subsequently updated for the PR09 Business Plan, to ensure a co-ordinated approach to the current and future treatment and recycling of sludge. The strategy has resulted in greater levels of treatment, inclusion of process controls, greater complexity of plant and the use of more highly qualified operators and agricultural advisors. The strategy is dynamic and developed in line with legislation, product market requirements and the need for business efficiency and the management of risk to the business.

Currently Southern Water produces both conventionally and enhanced treated products with the aim of recycling all biosolids to agricultural land. The treatment processes used are enzymic hydrolysis, mesophillic anaerobic digestion and sludge drying.

The production of an enhanced treated product (dried digested granules) has historically been driven by restrictions relating to planning approval, normally associated with the number of vehicle movements. However, latterly the need to secure and maintain the agricultural route has led to further investment in dryer technology. Southern Water has, for a considerable number of years, had sole reliance upon the agricultural landbank for the recycling of biosolids.

The long term strategy has been approached in a phased manner with recognition of current and proposed future legislation and the pressures these apply. It recognises the pressures upon the current recycling route (agriculture) and supports legislative change.

The specific legislation that currently applies to sludge, its treatment, disposal and recycling is the Sludge (Use in Agriculture) Regulations. Other legislation and codes of practice also impact on the process. Future legislative and policy changes may directly or indirectly impact upon our sludge operations, with the potential to decrease the available landbank further' with the revision of Directive 86/278/EEC potentially ruling out the recycling of some sludges to agricultural land.

The water industry has been awaiting the long promised revisions to the Sludge (Use in Agriculture) Regulations. The introduction of these revised regulations will, we believe, lead to increased security of the agricultural route for biosolids recycling. The failure to update the Regulations is putting pressure on the sustainability of this outlet.

The essential elements of the sludge strategy are as follows,

- Provision of sufficient treatment capacity to meet future demand
- Capital maintenance to provide continued operation and treatment
- Abandonment of liming as a treatment process
- Sustainable processing through the provision of enzymic hydrolysis and additional sludge storage

We recognise the impact that the processing and recycling of sludge has upon the environment, and it is our aim to reduce this impact. We intend to utilise the energy potential arising from the by-products of the sludge treatment process.

Southern Water has long since recognised the benefits of biogas utilisation in combined heat and power (CHP) plants having operated plants since the early 1990's. It is or intention to continue to operate such plants and to expand upon the current capacity.

Population growth in the southeast remains a significant driver for additional treatment capacity with a population increase of 270,000 predicted during the PR09 design horizon.

3.5. The Regulatory and Legislative framework for Water and Sewerage Companies

The water industry is governed by three principal regulators:

- Ofwat - economic regulator
- Environment Agency
- Drinking Water Inspectorate

The water companies are required to balance the competing demands of the EA and DWI (with their expectations of improving drinking water quality and environmental standards) against Ofwat's requirements for improving efficiency, improving customer satisfaction, and cost-benefit analysis for relevant capital expenditure. Tighter quality and environmental standards will often imply increased energy usage, and higher consequential CO2 emissions. The conflicting requirements between adaptation measures (with implied higher emissions) and carbon reduction targets must be resolved.

All water companies are funded on a five-year cycle with business plans (funding and outputs) approved by Ofwat. EA and DWI have significant input into the process in terms of particular environmental and quality issues which require resolution.

For the majority of the company's capital investment, Ofwat require the demonstration of positive cost-benefit on a scheme by scheme basis. For PR09 (the current price review period) Ofwat made it clear that schemes aimed solely at climate change adaptation would not be funded, but that all schemes should make allowance for the likely impact of climate change. Consideration of the costs and benefits of adapting to climate change are therefore included within each individual scheme.

The current price review period (AMP5) runs from April 2010 to March 2015, and barring any major legislative change, funding and outputs are unlikely to change significantly during this period. Planning for the next period (AMP6) will commence in 2012/13, with the Final Business Plans agreed late 2014.

The majority of water companies' activities are governed by the following legislation:

- Water Industry Act 1991
- Environment Act 1995
- Water Resources Act 1991
- Water Act 2003 (amending the 1991 WIA)
- Flood and Water Management Act 2010
- Environmental Permitting Regulations 2010

3.6. Organisational structure

The company's principal activities, in the context of managing climate change are:

- Corporate Strategy – dealing with regulators, and legislative change, and all other strategic issues
- Asset Management – understanding and managing investment in assets
- Operations – day to day management of the company's activities

The strategic role is entirely 'in-house'. Asset management is a mixture of in-house, out-sourced partnership working, and contracted resources (mainly design and construction work). Operational activities are managed by in-house staff, but a significant proportion of the labour force is out-sourced.

3.7. General effects of climate change

Climate change is driven by changes in mean global temperature. Since 1950, global mean temperatures have risen by approximately 0.5° C. Forecasts for the future range from 2-4° C to year 2100. Appendix 1 shows the summary of expected change in various parameters for 2050 and 2080.

Whilst these increases in temperature may appear relatively small, the consequential impact on other climactic factors, including changing weather patterns could be much more severe.

For the UK, aside from the principal effect of mean temperature, the main direct effects will relate to changing rainfall patterns, and an increase in sea level. More extreme weather is likely: periods of longer and more severe drought; increased incidence of extreme rainfall and consequential flooding; wetter winters; increased frequency of heat waves.

For the south-east of England, annual average rainfall is expected to remain broadly unchanged to 2080, but this disguises changes in seasonal variation, and also in daily and sub-daily rainfall patterns. In summary, winters are likely to be wetter, whilst summers are likely to be drier. The frequency of short, high intensity rainfall events is likely to increase in both summer and winter. Changes in seasonal rainfall will potentially affect river levels, with lower river levels in summer impacting on water resources, and also on the environmental impact of wastewater discharges from works and overflows. These effects are likely to have significant consequences for all aspects of the company's operations. Wetter winters may result in higher ground water levels and associated flooding and increased flows to wastewater treatment works.

Appendix 1, figures 1 to 9, shows graphs of low/medium/high scenarios for mean temperature rise, and percentage change in rainfall (winter and summer), illustrating the very wide range of possible outcomes.

Southern Water's region has a long coastline, and the majority of the main centres of population lie along the coast. Some areas are close to current sea-level, and in a few cases, below mean high water levels. A number of borehole sources are relatively close to the shoreline, and in conditions of extreme drought, are vulnerable to saline contamination. Sea-level rise is therefore likely to impact on the company's operations, both water and wastewater.

Appendix 1 figure 10 shows projected mean sea level rise around the country.

As well as direct impacts, as forecast by current climate impact models, there are other indirect secondary impacts, which are more difficult to predict, but which are nevertheless potentially very significant. These include, for example,

- Redistribution of population (both residential and tourist) as a result of temperature increase or water stress
- Changes in agricultural practice as a result of higher temperatures and a longer growing season
- Increase in algal growth and invasive species disrupting water quality
- Effects of higher temperature on treatment processes (water and wastewater)
- Effects of higher temperature on operation and life expectancy of electrical and ICA equipment (whether company's own or third party)
- Potential loss of power caused by more extreme events
- More extreme wetting/drying cycles leading to ground movement and consequent structural failure
- Transport and logistical difficulties caused by extreme weather conditions
- Changes in staff working practices arising from higher temperatures

The effects of climate change are thus very wide ranging, affecting all aspects of the company's operations. However, at a higher level (eg water resource planning, or changes in environmental standards) the impact of climate change can be seen as just one element of the need for water and sewerage companies to become increasingly flexible and adaptable to many challenges which may arise in the future.

To that extent, planning for adaptability is already part of 'business-as-usual' for water and sewerage companies.

3.8. Research

The water industry has been at the forefront of research into the effects of climate change, principally through WaterUK, and UK Water Industry Research (UKWIR). One of the earliest pieces of research carried out by UKWIR was the 2003 study into the impact of changing rainfall patterns on flood risk 'Climate Change and the Hydraulic Design of Sewerage Systems' reported in 12 volumes plus summary. The study was based on the outputs from UKCIP98, and UKCIP02.

WaterUK

WaterUK set up a Climate Change Focus Group in 2007, to enable all water companies to meet, and to discuss and progress topics related to climate change impact. Southern Water has been represented on this group since its inception.

In 2007 WaterUK appointed MWH Consultants to prepare a report on climate change impact for the water industry. The published report 'A Climate Change Adaptation Approach for Asset Management Planning' included an Excel workbook, with three principal tables:

- Climate change impacts on water industry assets
- Adaptation options in response to climate change Impacts
- Information source analysis

The tables covered all aspects of water company business, and identified relevant impacts and responses. This piece of research was used extensively in the compilation of this Adaptation Report. 4

UKWIR

UKWIR promotes and funds research across all aspects of water company business.

Each discipline (water distribution, sewerage, wastewater treatment customers etc) is co-ordinated by a Client Manager (from one of the water companies). UKWIR recognised in 2008 the need to bring together all climate change research across the disciplines. A Client Manager was appointed in early 2009.

A key report was 'Climate Change - A Programme of Research for the UK Water Industry' published in 2009. This report provides a first climate-related snapshot looking across the UK water industry and out to 2100. It identifies where significant uncertainties in the climate science remain, the nature and extent of impact and business risks, adaptation options, and where there are critical knowledge gaps and capacity within the industry. A long term, integrated, forward looking programme of climate change research needs is recommended that will allow the industry to put in place a sustainable response to adapting to climate change.

Key research projects related to climate change adaptation (either completed, in progress or planned for 2011-12) are:

- Climate Change, the Aquatic Environment and the Water Framework Directive
- Effects of Climate Change on River Water Quality
- Modelling the Effects of Climate Change on Water Quality in Rivers and Reservoirs
- Uncertainty & Risk in Supply/Demand Forecasting
- A Scoping Study to Identify Research Requirements to Assist the UK Water Industry in Dealing with Changing Patterns of Drought
- Assessment of the Significance to Water Resource Management Plans of the UK Climate Projections
- Effect of Climate Change on River Flows and Groundwater Recharge, A Practical Methodology: Synthesis Report
- Climate Change Uncertainty in Water Resource Planning
- Climate Change Implications for Water Treatment
- Climate Change Modelling for Sewerage Networks
- Climate Change and Wastewater
- Impact of Climate Change on Source Yields

4. Methodology for assessing risk

The potential impacts of climate change can be considered in many different ways. The principal effects of climate change for the water industry are:

- Increased temperature, and more extreme temperature variation
- Less rainfall, and longer periods of dry weather
- More rainfall, more intense rainfall and increased storminess
- Increased sea level

Tables 1 to 6 (Appendix 2) show the impact and consequences of these effects on each of the key parts of the company's activities:

- Water resources
- Water treatment
- Water distribution
- Wastewater collection and surface water management
- Wastewater treatment
- Sludge treatment and disposal

It can be seen from the tables that many of the consequences (for example stress on water resources, or flooding from the sewerage network) can arise from many different aspects of climate change.

The impacts and consequences of climate change can also be considered in terms of:

- Severity - consequences for customers (level of service) or for company (resources, either human or financial)
- Immediacy – how soon the effects may be felt, and whether the onset is likely to be gradual and progressive, or sudden
- Inertia – time required to respond to impact;
- Barriers to response – what legislative or regulatory barriers prevent response
- Business as usual – whether the effects of climate change are already embedded in company business

This impacts and consequences are summarised in Appendix 3, tables 7 to 12.

The consequences of climate change are considered below for each aspect of the company's business, and are considered against each of the criteria listed above.

5. Water resources

From Appendix 2 table 1 the four principal consequences are:

- Potential increased demand or reduced supply with consequent stress on water resources driven by temperature rise, change in rainfall patterns, or sea level rise.
- Risk of immediate loss of supply for a period of hours or potentially weeks driven by direct flooding of assets or loss of power supply.
- Potential contamination of water resources driven by direct flooding of assets.
- Increased microbial activity and invasive species giving rise to potential requirement for changes in the storage and treatment of raw water.

Increased demand or reduced supply

The Water Resources Management Plan (WRMP) is the strategy document that sets out our vision for the next 25 years. It looks in detail at our three main objectives of: achieving value for customers; resilience in a changing environment and facilitating growth in the South East of England. The WRMP takes into account consultation responses to the draft WRMP and joint discussions with regulators and others on how Sustainability Reductions might be implemented. We have also been an active member of Water Resources South East (WRSE) whose outputs have informed the final WRMP.

The full document is available for review, and therefore only the summary of the strategy is repeated below.

The challenges to water resources in this region are significant, but we believe that the options identified in the WRMP are robust and appropriate to meet these challenges. The balance of the various elements of the strategy given in the following summary will vary in the three different areas:

During AMP5

- Introduction of universal metering by 2015;
- Asset improvement schemes at a number of groundwater sources, as identified by the recent review of groundwater source performance;
- The optimum use of inter-zonal transfers, as identified by the investment model;
- Additional inter-zonal transfers, as identified by the investment model;
- The renewal of existing inter-company bulk supplies until the end of the planning period, at the rates at the time of contract renewal;
- New source development, if required, either to close any existing supply demand balance deficits, and/or to restore security of supplies as a result of Sustainability Reductions; and
- Any further investigation of new resource developments that were identified as part of the WRSE regional modelling work.

During the rest of the planning period to 2035

- It is currently envisaged that no further strategic resource developments will be required to meet Southern Water's needs under the company universal metering strategy;
- The strategy will deliver the objective of keeping to the target headroom line, through a delicate balance of a number of factors, including the following; source maximisation through potential licence variations; the refurbishment of a few small, currently disused groundwater sources, which may require fairly advanced treatment solutions; progressive leakage reduction, up to 19% below the current outturn level to offset the need for the development of major strategic schemes; and the introduction of further water efficiency savings where it is economic to do so;
- It should be noted that we have included the effects of climate change on both supply and demand side elements. However, these have only been introduced after the end of AMP5.
- Southern Water has reaffirmed its commitment to the WRSE modelling work, in the form of adopting the WRSE preferred regional options in its strategy in addition to those identified in the least-cost company-only strategy. Whilst the introduction of these schemes will lead to available headroom in excess of our target headroom requirements,

we believe that this will not contribute to any bill impact during AMP5, and demonstrates our continued commitment to the development of a regional solution.

Direct flooding of assets

We continue to review the risk of direct flooding to our water resource assets and are currently considering investment requirements for a number of priority sites. We anticipate some expenditure to protect priority sites before 2015. We also anticipate further expenditure in the AMP6 period (2010-15)

Loss of power supply

Key sites already have on-site standby generation or dual supplies to guard against power failure. Power companies will be assessing the vulnerability of their own sites to flooding or failure from other causes (high temperatures for example). The need for mobile generators, and for on-site fixed generators is periodically reviewed, and is part of business as usual for the company.

Increased microbial activity

Monitoring of water quality is a long-established element of water company business, and is a key regulatory and legislative component of our day-to-day work.

Any increase in microbial activity is likely to be relatively slow onset, and hence will be dealt with as it occurs.

Invasive species can be more difficult to deal with, as evidenced by the ‘killer shrimp’ found in one of Anglian Water’s raw water reservoirs.

6. Water treatment

From Appendix 2 table 2 the principal consequences are:

- Potential increased demand with consequent stress on water treatment capacity driven by temperature rise, or change in rainfall patterns.
- Reduced raw water quality caused by changes in daily or seasonal rainfall patterns, or saline intrusion into boreholes, requiring additional treatment processes
- Increased flooding of assets or access to assets, driven by change in rainfall patterns, or sea level rise, causing plant failure and loss of treatment process
- Potential contamination of water supply driven by direct flooding of assets.
- More severe wetting and drying cycles causing ground movement and structural failure.
- Risk of immediate loss of supply for a period of hours or potentially weeks driven by direct flooding of assets or loss of power supply.
- Increased microbial activity affecting treatment processes, causing discolouration or odour problems.

Increased demand

Increased demand may lead to higher peak flows, and consequent stress on water treatment capacity. Change in demand is likely to be relatively slow and predictable, and can be dealt with via normal processes of planned upgrades to the treatment processes.

Reduced raw water quality

Monitoring of water quality is a long-established element of water company business, and is a key regulatory and legislative component of our day-to-day work. Raw water quality is variable under normal circumstances, and is managed by balancing supplies and adjusting treatment processes.

In the longer term raw water quality may be consistently worse, either because of increased demand, or stress on the supply itself (for example from saline intrusion).

Change in water quality is likely to be relatively slow and predictable, and can be dealt with via normal processes of planned upgrades to the treatment processes.

Flooding of assets

Flooding is unlikely to have a major effect on the water distribution system, unless the supply system (treatment works and pumping stations) also fail. The main danger is of loss of pressure within the distribution system leading to a risk of contamination of the pipelines, and potentially a long recovery time to disinfect and flush the system.

Structural failure

Increased ground movement caused by more severe wetting and drying cycles could lead to increased rates of structural failure. Structural failure on water treatment plants is a relatively rare occurrence. Such damage would normally be visible, with relatively slow change over a period, and can therefore be managed during normal business activity, but the volume, and therefore cost, of necessary remedial work may increase in future.

Loss of power supply

Key sites already have on-site standby generation or dual supplies to guard against power failure. Power companies will be assessing the vulnerability of their own sites to flooding or failure from other causes (high temperatures for example). The need for mobile generators, and for on-site fixed generators is periodically reviewed, and is part of business as usual for the company.

Increased microbial activity

Monitoring of water quality is a long-established element of water company business, and is a key regulatory and legislative component of our day-to-day work.

Any increase in microbial activity is likely to be relatively slow onset, and hence will be dealt with as it occurs.

7. Water distribution

From Appendix 2 table 3 the principal consequences are:

- Potential increased demand with consequent stress on water distribution system, driven by temperature rise, or change in rainfall patterns.
- Increased flooding of assets or access to assets, driven by change in rainfall patterns, or sea level rise, causing plant failure
- Potential contamination of water supply driven by direct flooding of assets.
- More severe wetting and drying cycles causing ground movement and structural failure of pipelines leading to increased leakage
- Risk of immediate loss of supply for a period of hours or potentially weeks driven by direct flooding of assets or loss of power supply.
- Increased microbial activity, causing discolouration or odour problems.

Increased demand

Increased demand may lead to higher peak flows, and consequent lower pressure. Incidents of low pressure are already reported to Ofwat, and managed by water companies as part of day-to day business. Change in demand is likely to be relatively slow and predictable, and be dealt with via normal processes of hydraulic modelling, and planned upgrades to the system.

Flooding of assets

Flooding is unlikely to have a major effect on the water distribution system, unless the supply system (treatment works and pumping stations) also fail. The main danger is of loss of pressure within the distribution system leading to a risk of contamination of the pipelines, and potentially a long recovery time to disinfect and flush the system.

Structural failure

Increased ground movement caused by more severe wetting and drying cycles could lead to increased rates of structural failure, and increased leakage. Leakage management is a key part of the process of managing the water distribution system.

The principal consequence is therefore likely to be an increase in investment required to maintain the structural condition of the distribution system, to maintain or reduce leakage levels.

Loss of power supply

Key sites already have on-site standby generation or dual supplies to guard against power failure. Power companies will be assessing the vulnerability of their own sites to flooding or failure from other causes (high temperatures for example). The need for mobile generators, and for on-site fixed generators is periodically reviewed, and is part of business as usual for the company.

Increased microbial activity

Monitoring of water quality is a long-established element of water company business, and is a key regulatory and legislative component of our day-to-day work.

Any increase in microbial activity is likely to be relatively slow onset, and hence will be dealt with as it occurs.

8. Wastewater collection and surface water management

From Appendix 2 table 4 it can be seen that the principal consequences are:

- Potential changes in daily water usage (higher peak flows) with consequent stress on wastewater collection system, driven by temperature rise or demographic change
- Increased flooding driven by change in rainfall patterns, or sea level rise.
- Need for pumped outfalls to drain tide-locked outfalls, during extreme tides.
- Increased flooding driven by higher water table, and consequent infiltration, arising from either wetter winters, or rising sea level.
- Increased flooding caused by increased deposition of solids and consequent blockage, arising from longer dry periods.
- Increased microbial activity (mainly H2S attack) giving rise to more frequent structural failure.
- More severe wetting and drying cycles causing ground movement and structural failure of pipelines.
- Risk of immediate loss of network for a period of hours or potentially weeks driven by direct flooding of assets or loss of power supply.

Flooding

Flooding is the most severe consequence of climate change on the wastewater collection system. This may be caused by:

- Hydraulic overload caused by increased rainfall, increased infiltration or sea level rise.
- More frequent blockage or collapse of sewers.

The consequences for customers can be severe, particularly in major flooding events. The past two decades have seen a dramatic increase in the frequency of severe flooding (Glasgow, Carlisle, Hull, York, Portsmouth etc), and arguably the effects of climate change are already being felt.

Southern Water has been building models of its sewerage networks since the early 80's, as part of its overall responsibilities to understand the capacity of its networks. This aspect of asset management is therefore already embedded in company business. The design standard for sewerage networks is not enshrined in law, but is usually recognised as typically a 1 in 30 year return period (3.3% chance of flooding in any year).

As a result of the Pitt Review and the consequent changes in legislation (Flood and Water Management Act 2010 and Flood Risk Regulations 2009), severe flooding (from above the typical sewer design standard) is the focus of attention. The F&WM Act puts upper tier authorities in the role of Lead Local Flood Authorities (LLFA's), with a duty to investigate flooding incidents, to set up strategic flood management boards, and to prepare flood risk assessments, flood risk and hazard amps, and a flood risk strategy for their area. One of the key components of the legislation is the requirement for all flood management authorities to cooperate and to share data. The majority of LLFA's have already begun this process and Southern Water is closely engaged in the process, sharing knowledge and data.

A major issue for low-lying coastal areas is groundwater flooding. This is not the responsibility of the water companies, but nevertheless can have a major impact on company activity. In a typical low-lying poorly drained area, ground water levels are likely to be high during winter months, causing infiltration into sewers and drains. Water companies can ensure their own pipelines are leak-tight, but have limited powers to deal with private drains. If garden flooding occurs in such areas, it is common practice to allow flood waters to drain into the public sewerage system, either through direct connection, or by lifting inspection covers to allow water to drain away. This practice is extremely difficult to detect, and almost impossible to prevent.

The solution is therefore to engage with the LLFA to improve land drainage. However, the principal barrier to resolution is cost. Groundwater flooding (and other flooding caused by higher groundwater levels is likely to be one of the most intractable flooding problems affecting householders in such areas. Ultimately, the viability of certain developed areas may be called into question, particularly as a result of rising sea-level.

Pumped outfalls

Steadily rising sea-level will cause a progressive increase in flooding of low-lying coastal, estuarial and river communities. This ultimately may lead to an increased requirement for pumped outfalls for surface water disposal. However, the responsibilities in this respect are not entirely clear. For example, rising sea-level will lead to higher groundwater levels in low-lying coastal areas. In the first instance, this is likely to lead to inundation of sewer networks which could be dealt with through increased pumping to sea (water company responsibility). However, it could equally, and more satisfactorily be dealt with through improved land drainage (local authority responsibility).

Blockage and structural failure

Blockage and structural failure have always been a key part of water company business, and the analysis and understanding of risks part of business as usual. The issue therefore is the scale of any increase in failure, and the cost of maintaining current performance standards. Sewer deterioration is a complex and poorly understood aspect of sewer network management, notwithstanding considerable effort on research.

Risk of asset failure caused by direct flooding (either of the asset itself, or its power supply) has been given more prominence recently. Many larger pumping stations have on-site standby generation to guard against power failure. Work is ongoing to understand the risk of inundation of key sites. Specific analysis was carried out for PR09, and the only asset identified as a major risk was Eastney Pumping Station in Portsmouth. A scheme was proposed to provide additional protection, but rejected by Ofwat. Work is continuing, to provide further justification for this scheme.

9. Wastewater treatment

From Appendix 2 table 5 it can be seen that the principal consequences are:

- Potential changes in daily water usage (higher peak flows) with consequent stress on wastewater treatment system, driven by temperature rise or demographic change
- Lower summer river flows or higher temperatures, requiring tighter discharge standards
- Increased microbial action affecting treatment processes, driven by increased mean temperatures
- Increased infiltration driven by higher water table arising from either wetter winters, or rising sea level, affecting treatment processes
- Increased saline infiltration driven by higher water table, arising from rising sea level, affecting treatment processes
- Increased flooding of assets or access to assets, driven by change in rainfall patterns, or sea level rise, causing plant failure and pollution
- Increased microbial activity (mainly H2S attack) giving rise to more frequent structural failure.
- More severe wetting and drying cycles causing ground movement and structural failure.
- Risk of immediate loss of network for a period of hours or potentially weeks driven by direct flooding of assets or loss of power supply.

Increased demand

Increased demand may arise from demographic change, or from changes in daily water usage. Flow to treatment is constantly monitored at most treatment works; water usage is monitored through water into supply data and meter records; future growth patterns are regularly assessed. Dealing with increased demand is therefore a well-established part of business as usual: change is likely to be relatively slow paced, and largely predictable.

There appear to be no barriers to the principles of dealing with increased demand, except the ability of the aquatic environment to deal with increasing load, as discussed below.

Changes to treatment processes

Increased average, or extreme summer temperatures may affect treatment processes. In some cases, increased average temperatures could provide benefits in terms of improved treatment processes. Saline infiltration on coastal sites may present problems for treatment processes.

The quality of effluent discharge is constantly monitored, and changes in plant performance are likely to be slow, and to an extent predictable.

Management of discharge quality is a key part of the day-to-day business activities. There are unlikely to be significant technical barriers which cannot be overcome, although the cost of maintaining the quality of discharges may be high.

Tighter discharge standards

Seasonal change in rainfall is likely to give rise change in river levels, particularly lower river flows during summer. In order to maintain environmental standards, higher quality discharges may be necessary.

The south-east of England is already stressed in certain areas, where the environment is no longer capable of absorbing the impact of human activity. Several wastewater treatment plants are at the peak of operating capacity and ‘best available technology’. Future scientific developments may deliver different processes to achieve higher standards, but there is likely to be significant cost attached to this.

Alternatively, development in certain areas of the south-east may have to be curtailed, if environmental impact is to be avoided. The issue of consent standards and the environment rests with the Environment Agency. Environmental schemes are dealt with the ‘Quality’ schemes in the company’s Business Plans. A suite of environmental schemes has been agreed for AMP5 (Apr 2010 to Mar 2015) and a further programme will be developed with the agency for AMP6 (2015-2020). The consideration of environmental quality is business as usual for both Environment Agency and water companies.

Direct flooding of assets

Direct flooding of assets, or access to assets, presents a threat in the current climate, but the frequency of severe flooding is likely to increase as a result of climate change.

Vulnerable assets may require additional protection, such as earth bunding to reduce the risk of flooding, or may require mitigation measures to ensure that if a site is flooded, damage is limited, and downtime reduced. Such measures might include raising electrical equipment above flood level, or providing increased remote monitoring and operation of sites to maintain service.

Vulnerability of wastewater treatment sites was considered in the Business Plan for PR09, and whilst a number of sites were considered at risk, none was considered at sufficiently high risk to take action at present.

Data on flood risk is being reviewed, and vulnerability to flooding will be re-assessed for the next Business Plan in 2014.

Structural failure

Structural failure on wastewater treatment plants is a relatively rare occurrence. Most structural damage arises from H2S attack on concrete structures. Such damage would normally be visible, with relatively slow change over a period, and can therefore be managed during normal business activity, but the volume, and therefore cost, of necessary remedial work may increase in future.

Loss of power supply

Key sites already have on-site standby generation or dual supplies to guard against power failure. Power companies will be assessing the vulnerability of their own sites to flooding or failure from other causes (high temperatures for example). The need for mobile generators, and for on-site fixed generators is periodically reviewed, and is part of business as usual for the company.

10. Sludge treatment and disposal

From Appendix 2 table 6 it can be seen that the principal consequences are:

- Risk of increased odour driven by higher temperatures
- Risk of increase in septicity of sewage, driven by higher temperatures
- Risk to existing recycling routes as a result of higher temperature, or increased summer storminess
- Risk to sludge stockpiles caused by more intense summer rainfall

Increased odour

Management of odour from the sludge treatment processes and recycling routes is embedded in current practice. Any increase in odour is likely to be slow onset, and therefore managed within existing processes.

Higher levels of investment may be required to avoid increased complaints about odour.

Increased septicity

Higher temperatures may cause an increase in septicity of sewage and resulting sludge, and more require changes to treatment processes. Higher levels of investment may be required to maintain treatment standards.

Risk to recycling outlets

Climate change may pose a risk to the continued use of agricultural land as the sole method for recycling This was given full consideration in the company's sludge management strategy published as part of the PR09 Business Plan, and is therefore embedded as part of day-to-day business activities.

Sludge stockpiles

Sludge stockpiles may be at risk from more intense summer rainfall, may therefore require additional investment to provide appropriate protection.

11. Barriers to Adaptation

The principal barrier to climate change adaptation is likely to be the cost of adaptation measures, and the associated impact on water company customer bills. The current approach by Ofwat using 'willingness to pay' techniques is unlikely to yield significant support for funding of adaptation measures early enough for the measures to be effective. Studies undertaken for PR09 suggest that customers are unwilling to fund investment which appears to be of no direct benefit to themselves. Flooding for example, is recognised as having severe consequences on households affected, but generally affects relatively few people, and there is consequently a reluctance to agree to a significant increase in bills to help alleviate flooding.

The public at large remain sceptical about the reality of climate change, and this scepticism is frequently underlined by segments of the press which question climate change science, often confusing climate with weather. Influencing public opinion is key to persuading customers of the reality of climate change, the potential threats, and the need to invest. A major national campaign by government is required to help change opinions, although it seems that the government itself is not wholly convinced of the seriousness of the threat that climate change poses.

The relatively short-term nature of the current regulatory process is a potential barrier to adaptation. Ofwat generally require high levels of certainty in business plans before accepting the need to invest. There is clearly (and understandably) a great deal of uncertainty regarding the likely impacts of climate change. The probabilistic nature of the UKCP09 projections provide a more realistic view of the uncertainties and potential range of impacts, but does not necessarily provide clear enough evidence of the threats posed. Where long-term investment is required Ofwat should take a broader view of the likely threat rather than requiring evidence of an actual risk.

As well as the general uncertainties around climate change, there are specific issues which are not well understood, or fully covered by UKCP09 data. The two principal areas of concern are:

- The probability of extended periods of drought (2-3 years), and the consequential risk to water resource and the need to invest early to protect supply.
- Downscaling of rainfall data to sub-daily predictions, and in particular the increased threat of major cyclonic storms. Given the large numbers of major floods in the UK during the past 10-12 years (almost one major event per year) it is conceivable that we are already witnessing the effects of climate change.

Further research is needed to investigate these two aspects.

With the threat of sea-level rise, action will be needed to protect vulnerable communities in low-lying coastal areas. Raising sea defences may prevent catastrophic flooding at times of extreme high tide, but rising sea-level will also affect ground-water levels. Responsibility for coastal defence, land drainage and groundwater flooding are shared between the EA and local authorities. However, the consequences of higher ground water levels arising from inadequate attention to land drainage are likely to be felt first by water companies, through inundation of sewerage systems, either from infiltration (into public sewers or private drains), or from householders lifting inspection covers and allowing flood water to drain into the foul sewerage system. Evidence of this can already be seen in some coastal areas. There is therefore a need for all parties to work together to ensure that adequate land drainage is maintained and improved, particularly when viewed in the context of sea-level rise.

Water company activities are heavily reliant on power, telecoms and transport links, all of which face threats from climate change. A failure of utilities to work together may be a significant barrier to adaptation. Southern Water is investing in generating plant at sites seen represent significant risks in the event of power failure. Our ability to use these generators to feed power back into the grid at times of peak (national) demand is a considerable incentive to investing in, and maintaining such plant.

12. Opportunities

This report has focused principally on the threats and risks posed by climate change, rather than opportunities. In a 'normal' retail or manufacturing business, change will often offer opportunities, either by producing more of a particular product, or adapting and developing new products. The supply of raw resource would not normally present a restriction (in the context of climate change).

The water industry has fewer opportunities to adapt its business in this way. We are required to supply good quality potable water, and to collect and treat wastewater. We are a heavily regulated business with relatively little freedom to adapt. The majority of our business is directly related to the environment, through for example, the availability of water resources; our response to rainfall and flooding; and our impact on the environment through treated wastewater effluent discharge.

There are therefore relatively few obvious opportunities. There may for example be additional opportunities for sludge recycling to land to aid water retention, and there may be advantages for treatment processes operating at slightly higher temperatures. These two examples are extremely uncertain, and it is as likely that other pressures will negate any potential opportunities.

13. Company staff

The most likely impact of climate change on is temperature change. Changes in daily temperature patterns may prompt a change in working time, for example an earlier start, following Mediterranean practice. More air conditioning may be required in offices to cope with high ambient temperatures.

Long periods of extreme high temperature could cause problems with sickness or heat stress. Extremes of wet or freezing weather may give rise to difficulties in travelling to site or office.

These impacts are unlikely to be sudden onset, and may not be evident within the next 30 years. Onset is likely to be slow, changes in working patterns are likely to be incremental, and barriers to change few.

14. Premises & IT

As with staff, the most likely impact of climate change on premises and IT is temperature change. More air conditioning may be required in offices to cope with high ambient temperatures, and to prevent over-heating of IT equipment.

High ambient temperatures are dealt with elsewhere in the world, and there should be no significant barriers to overcome. This is largely part of business as usual.

15. Logistics, power, communications

Severe flooding is likely to be the principal impact on logistics, and power or communications failure. There have been several major events over the last decade which have demonstrated how rapidly normal working practice can be completely disrupted with sever consequences for the public.

To a large extent, power and communications are in the hands of third-party suppliers, who will themselves be reviewing the impact of climate change – for example high temperatures in transformers, or flooding of critical sites.

In the case of extreme flooding, transportation of flood defence equipment and bottled water supplies is a key issue. Recent events have demonstrated the difficulties of co-ordinating response to major flood events. The Pitt review of the 2007 floods affecting the Midlands and Hull made a number of recommendations affecting all category 1 and 2 responders. Some of the recommendations have been incorporated into law through the Flood and Water Management Act 2010.

WaterUK set up a task-and-finish group to track progress on the recommendations specific to the water industry. All companies have responded to the recommendations and significant steps have been taken for example, enabling equipment and resources to be shared between companies in emergencies.

The Flood and Water Management Act and Flood Risk Regulations (FRR) place a firm duty on upper tier local authorities to understand flood risk (through the Preliminary Flood Risk Assessment, Flood Risk and Hazard maps, and Flood Risk Strategies). The Act also places a duty on other flood risk authorities to share data and co-operate with these authorities.

Southern Water has actively engaged with the LLFA's on the Defra funded Surface Water Management Plans, and also on the Strategic Flood Management Boards. We will continue to assist the LLFA's in their duties under the FRR and F&WM Act.

16. Customer Expectation and Bill Impacts

Serviceability standards for water supply and wastewater collection have risen significantly since privatisation in 1989, and both CCWater and Ofwat continue to monitor serviceability with a view to delivering further improvements. Climate change presents a risk to standards on all fronts: water resource and quality; water distribution; waste water collection and surface water management; and waste treatment and environmental standards.

Whilst most of the risks arising from climate change can be avoided or alleviated (with the possible exceptions of severe flooding caused by sea level rise or extreme rainfall), the cost of maintaining current standards may be extremely high. This is likely to be reflected in rising customer bills. A balance will therefore need to be achieved between serviceability standards and costs, involving all agencies: government, Ofwat CCWater and water companies.

17. Periodic Price Reviews and Business Plans

In the company business plan for PR09, the two key elements relating to climate change were:

Flooding of company assets from sea or surface water (fluvial or pluvial).

The company presented evidence of risk to a number of key sites, both water and wastewater, and the need to invest in resilience measures (principally bunding) to protect these sites. Ofwat rejected these proposals, citing insufficient evidence of the level of risk.

Flooding of properties due to hydraulic overloading of the sewerage network.

The funding provision to reduce the risk of flooding was subject to 'willingness to pay' studies for customers. Whilst many customers consider that flooding is has a serious impact on those affected, in reality it affects relatively few people, and consequently customers are generally unwilling to see significant increases in water charges to fund flood alleviation schemes.

Sufficient funding was made available to make reductions to the DG5 register (properties at risk of internal flooding more frequently than once in ten years), where the cost of the scheme was shown to be cost beneficial (when compared with customers willingness to pay). Evidence was also provided to support the need to carry out a number of other schemes, recognised as not cost-beneficial, but which were long-standing or frequent enough to warrant special consideration. Ofwat rejected all these schemes.

Whilst the number of internally flooded properties from hydraulic overload is falling at present, climate change may reverse this trend, and the current methodology for assessing the worth of a scheme may need to be revisited. In particular, Ofwat rejected all flood alleviation schemes related solely to external flooding, and the number of properties affected by external flooding continues to rise. Action is required to reverse this trend.

Actions for PR14 and PR19

Further work will be carried out on the two key issues of water resources and flooding (company assets and customer's property).

18. Summary and Conclusions

Water companies, in comparison with other industries, have relatively little control over demand, either water supply, or wastewater disposal. Water usage is driven by growth and new development, and water resources are influenced by long-term (annual) rainfall variability. Wastewater and surface water collection and treatment is similarly affected by growth and new development, and subject to short-term (sub-daily) rainfall patterns. Drinking water quality is subject to UK and EU legislation, and governed by Drinking Water Inspectorate (DWI as regulator. Wastewater quality and sludge recycling are similarly subject to UK and EU legislation, and government principally by Environment Agency as regulator.

The water industry thus has to deal with many uncertainties outside its control, and must necessarily be flexible and adaptive in dealing with each new challenge, from whichever source. There are few completely new risks posed by climate change although some risks may increase, because of either increased probability, or increased severity. To that extent, planning for adaptability is already part of 'business-as-usual' for water and sewerage companies.

We have a team dedicated to climate change mitigation, managing renewable energy and energy efficiency across the company. Adaptation measures, however, cover many aspects of the company's work (asset management, operations, construction etc) and responsibilities for adaptation are similarly widely spread with no single manager having overall responsibility. Notwithstanding this, there is a coherent strategy for climate change adaptation measures in the key areas of the preparation of the Water Resources Management Plan and the 5 yearly Business Plan.

The effects of climate change are very wide ranging, affecting all aspects of the company's operations. However, at a higher level (eg water resource planning, or changes in environmental standards) the impact of climate change can be seen as just one element of the need for water and sewerage companies to become increasingly flexible and adaptable to many challenges which may arise in the future.

The principal impacts are from changes in rainfall patterns (both seasonal/annual and sub-daily), and from sea-level rise. Changes in seasonal and annual rainfall patterns could have a major impact on water resource, whilst changes in daily and sub-daily rainfall patterns could give rise to increased flooding of company assets, affecting the ability to deliver a service, or direct flooding of customer's property.

The threat of long-term rainfall shortfall affecting water resource is ever-present, and is dealt with in the company Water Resource Management Plan. The impact can be seen as severe, medium-term (slow onset), significant inertia, with regulatory barriers (in terms of providing evidence of need), but equally part of business as usual. There are also gaps in knowledge: the UKCP09 projections do not deal with the likelihood of extended periods of drought.

The threat posed by extreme daily/sub-daily rainfall causing flooding is also ever present, and is considered as part of the drainage area planning process, and the maintenance of the DG5 registers. The impact can be seen as severe, immediate, significant inertia, with regulatory barriers (in terms of delivering cost beneficial schemes), but equally part of business as usual. There are also gaps in knowledge: cyclonic rainfall is not well understood or easily modelled, and hence the UKCP09 projections do not provide sufficient data. In addition, responsibility for flooding is highly complex, being split between a number of private and public agencies, as well as private landowners. The Flood and Water Management Act has the potential to remove a number of obstacles, with much clearer definition of responsibilities for each of the agencies involved, and also the requirements for Sustainable Drainage Systems (SuDS) for new development.

Sea-level rise will affect both water resource availability (through the risk of saline infiltration into coastal boreholes), and the risk of flooding, whether direct tidal flooding, or resulting from higher groundwater levels. Sea-level rise is more easily predictable, at least for the next 30-50 years. It can be characterised as severe, slow-onset, with significant inertia, and barriers to implementation, principally cost.

Southern Water
Adapting to Climate Change

The water sector has long been aware of the risks posed by climate change, and has promoted research on the subject since the mid 90's, covering all aspects of water company activities.

In addition to work on adaptation measures, Southern Water is also implementing a range of initiatives during AMP5 to reduce energy consumption and CO_2 emissions to mitigate climate change.

References

Adapting to Climate Change: helping key sectors to adapt to climate change - Statutory Guidance to Reporting Authorities (Defra 2009)

Adaptation Reporting Power - Supplementary Guidance for Reporting Authorities (Environment Agency 2010)

UKCP09 – Climate Change Projections – (UK Climate Impacts Programme 2009)

National Infrastructure Plan – HM Treasury (2010)

Adapting to climate change in the infrastructure sectors - PwC LLP (2010)

Water Resources Management Plan (Southern Water 2009)

UKWIR reports catalogue

One Year On - Report of the Water UK Flooding Implementation Group - Lessons learned from the floods of summer 2007 (WaterUK 2009)

Appendix 1

Extracts from UKCP09 projections for temperature, precipitation and sea level rise

Key findings for South East England, 2050s
(Abstract from UKCP09)

Medium emissions scenario

The wider range is from the lowest to highest value for all emissions scenarios and three (10, 50, and 90%) probability levels for each 30-year time period. Under medium emissions, the central estimate of increase in winter mean temperature is 2.2ºC; it is very unlikely to be less than 1.1ºC and is very unlikely to be more than 3.4ºC. A wider range of uncertainty is from 0.9ºC to 3.8ºC.

Under medium emissions, the central estimate of increase in summer mean temperature is 2.8ºC; it is very unlikely to be less than 1.3ºC and is very unlikely to be more than 4.6ºC. A wider range of uncertainty is from 1.1ºC to 5.2ºC.

Under medium emissions, the central estimate of increase in summer mean daily maximum temperature is 3.7ºC; it is very unlikely to be less than 1.4ºC and is very unlikely to be more than 6.6ºC. A wider range of uncertainty is from 1.2ºC to 7.4ºC.

Under medium emissions, the central estimate of increase in summer mean daily minimum temperature is 3ºC; it is very unlikely to be less than 1.3ºC and is very unlikely to be more than 5.1ºC. A wider range of uncertainty is from 1.2ºC to 5.7ºC.

Under medium emissions, the central estimate of change in annual mean precipitation is 0%; it is very unlikely to be less than –5% and is very unlikely to be more than 6%. A wider range of uncertainty is from –6% to 6%.

Under medium emissions, the central estimate of change in winter mean precipitation is 16%; it is very unlikely to be less than 2% and is very unlikely to be more than 36%. A wider range of uncertainty is from 1% to 40%.

Under medium emissions, the central estimate of change in summer mean precipitation is –19%; it is very unlikely to be less than –41% and is very unlikely to be more than 7%. A wider range of uncertainty is from –43% to 16%.

Southern Water
Adapting to Climate Change

Key findings for South East England, 2080s
(Abstract from UKCP09)

Medium emissions scenario

The wider range is from the lowest to highest value for all emissions scenarios and three (10, 50, and 90%) probability levels for each 30-year time period. Under medium emissions, the central estimate of increase in winter mean temperature is 3ºC; it is very unlikely to be less than 1.6ºC and is very unlikely to be more than 4.7ºC. A wider range of uncertainty is from 1.4ºC to 5.7ºC.

Under medium emissions, the central estimate of increase in summer mean temperature is 3.9ºC; it is very unlikely to be less than 2ºC and is very unlikely to be more than 6.5ºC. A wider range of uncertainty is from 1.4ºC to 8.1ºC.

Under medium emissions, the central estimate of increase in summer mean daily maximum temperature is 5.3ºC; it is very unlikely to be less than 2.3ºC and is very unlikely to be more than 9.2ºC. A wider range of uncertainty is from 1.4ºC to 11.5ºC.

Under medium emissions, the central estimate of increase in summer mean daily minimum temperature is 4.2ºC; it is very unlikely to be less than 2.1ºC and is very unlikely to be more than 7.2ºC. A wider range of uncertainty is from 1.4ºC to 9.1ºC.

Under medium emissions, the central estimate of change in annual mean precipitation is 1%; it is very unlikely to be less than –5% and is very unlikely to be more than 6%. A wider range of uncertainty is from –7% to 9%.

Under medium emissions, the central estimate of change in winter mean precipitation is 22%; it is very unlikely to be less than 4% and is very unlikely to be more than 51%. A wider range of uncertainty is from 4% to 67%.

Under medium emissions, the central estimate of change in summer mean precipitation is –23%; it is very unlikely to be less than –48% and is very unlikely to be more than 7%. A wider range of uncertainty is from –57% to 13%.

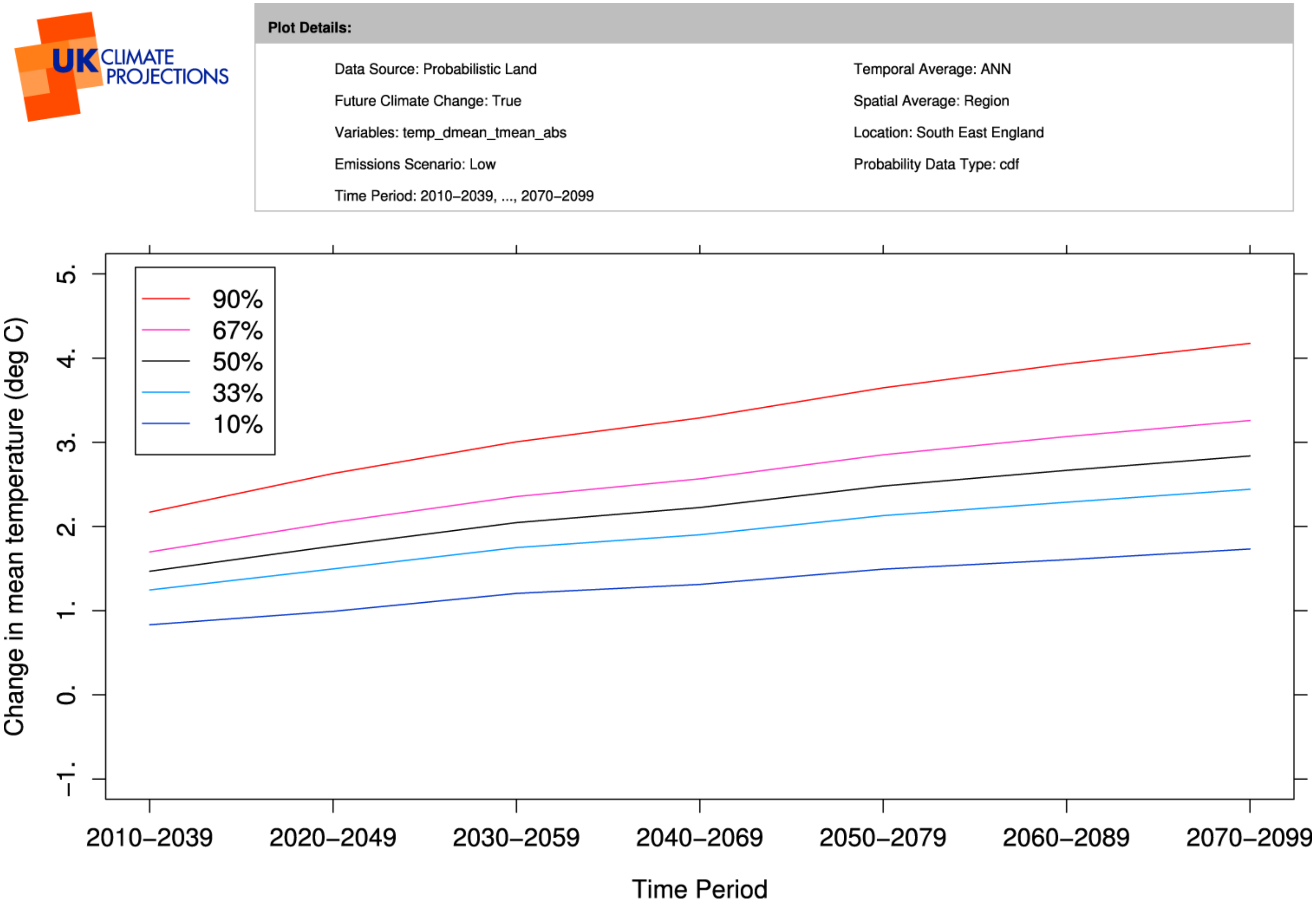

FIGURE 1 – Mean Temperature Change – Low Emissions Scenario

Plot Details:

Data Source: Probabilistic Land	Temporal Average: ANN
Future Climate Change: True	Spatial Average: Region
Variables: temp_dmean_tmean_abs	Location: South East England
Emissions Scenario: Medium	Probability Data Type: cdf
Time Period: 2010–2039, ..., 2070–2099	

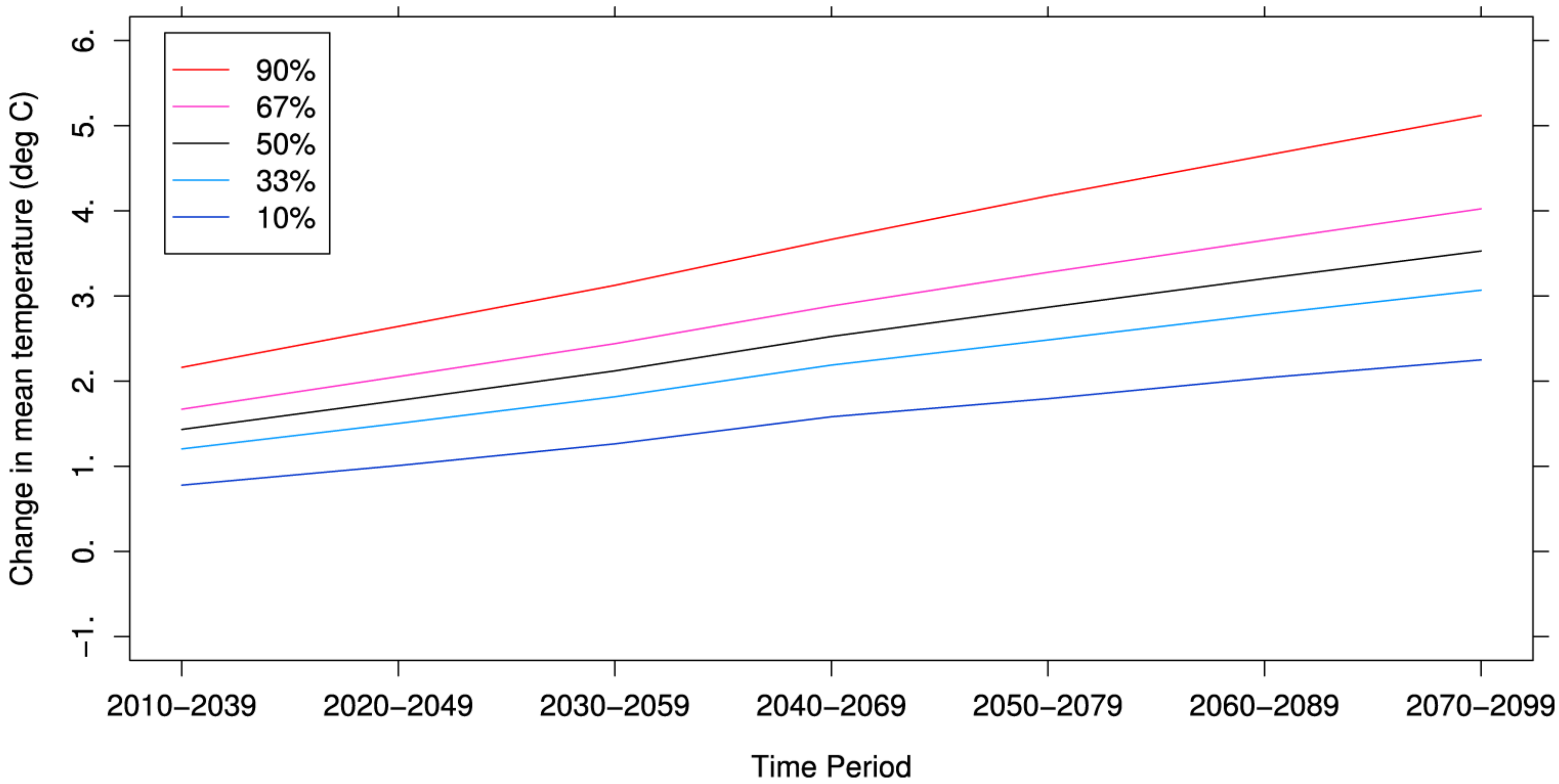

FIGURE 2 – Mean Temperature Change – Medium Emissions Scenario

Plot Details:

Data Source: Probabilistic Land
Future Climate Change: True
Variables: temp_dmean_tmean_abs
Emissions Scenario: High
Time Period: 2010–2039, ..., 2070–2099

Temporal Average: ANN
Spatial Average: Region
Location: South East England
Probability Data Type: cdf

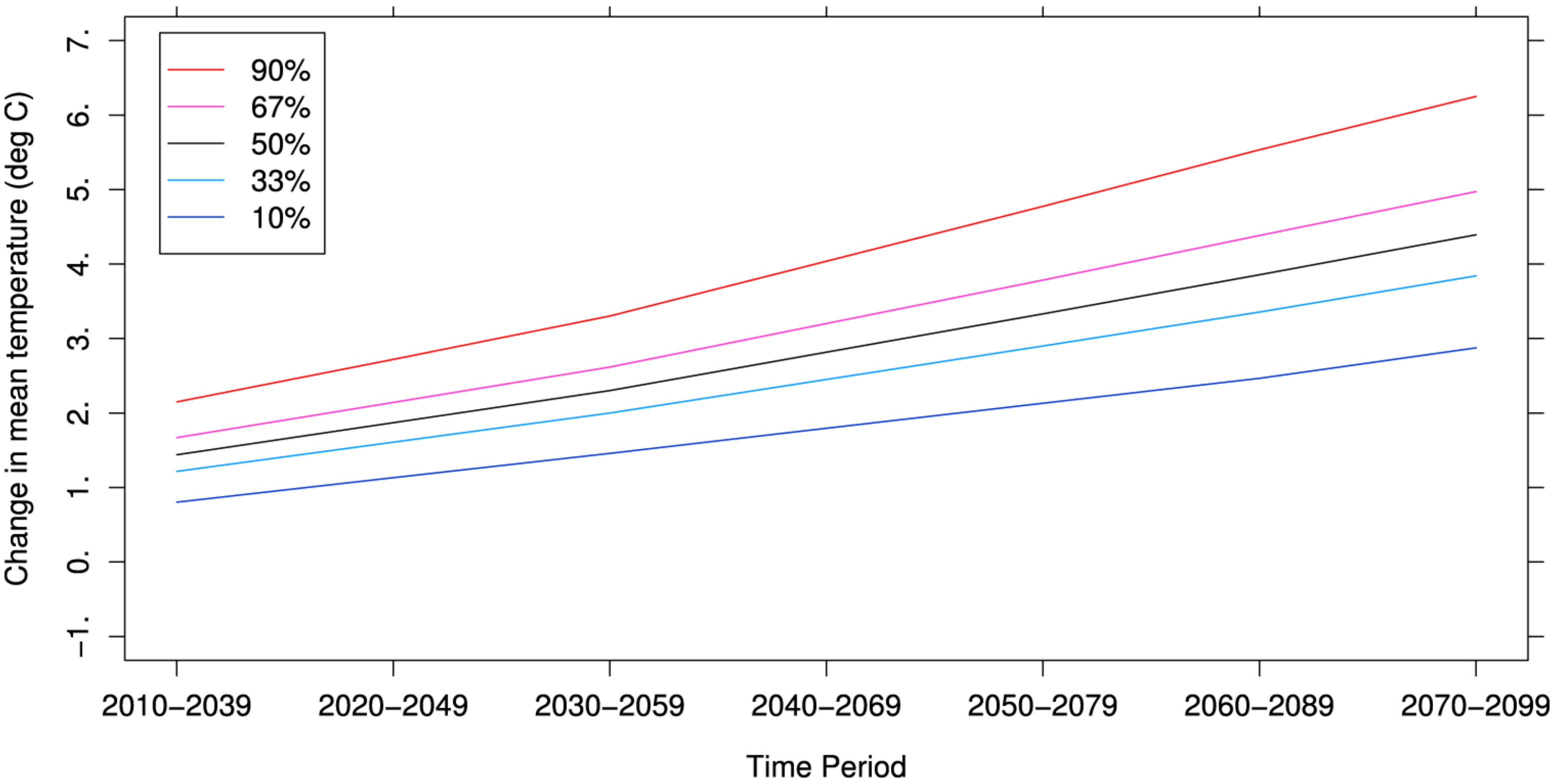

FIGURE 3 – Mean Temperature Change – High Emissions Scenario

Plot Details:

Data Source: Probabilistic Land
Future Climate Change: True
Variables: precip_dmean_tmean_perc
Emissions Scenario: Low
Time Period: 2010–2039, ..., 2070–2099
Temporal Average: DJF
Spatial Average: Region
Location: South East England
Probability Data Type: cdf

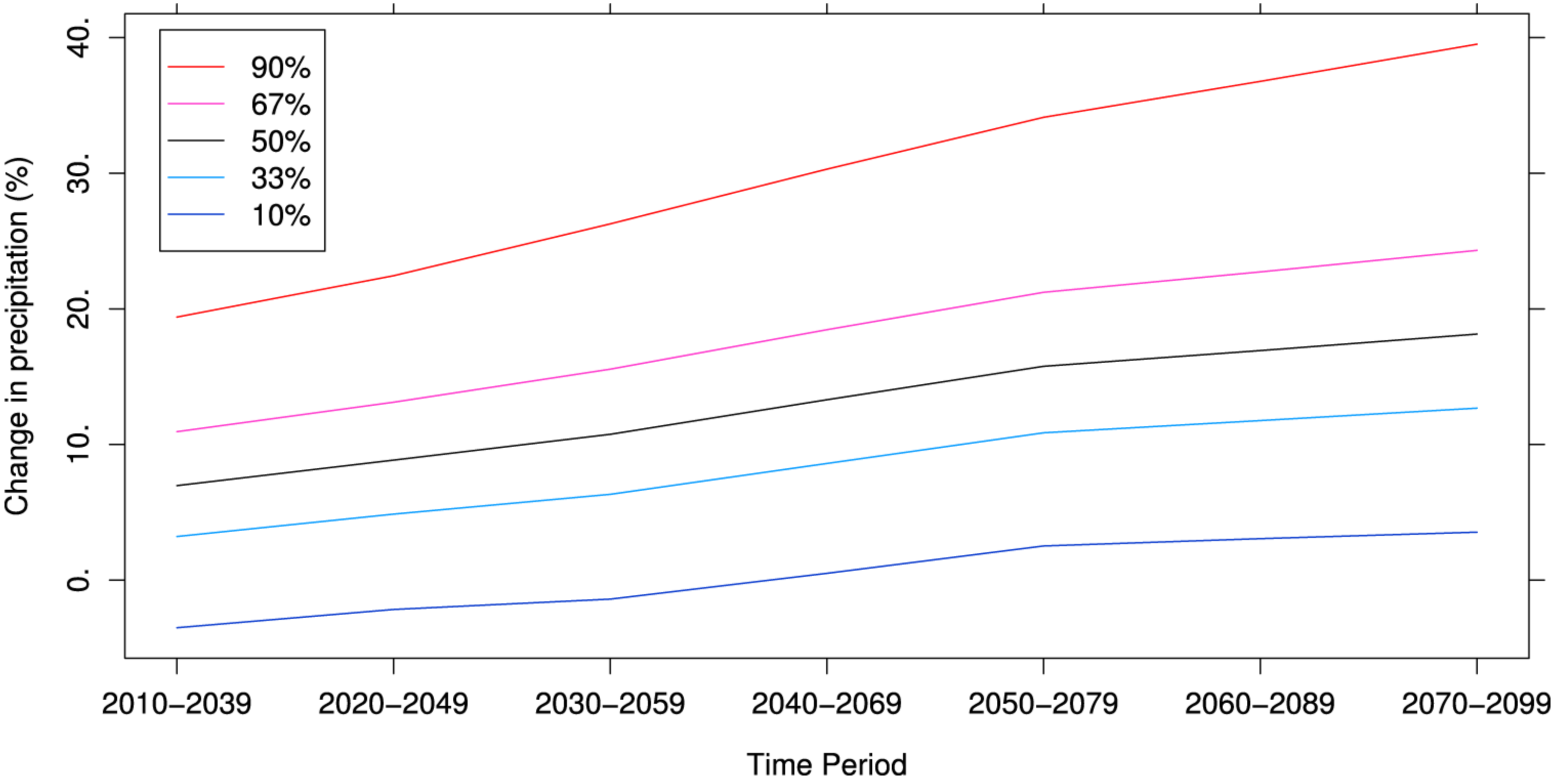

FIGURE 4 – Change in Winter Precipitation – Low Emissions Scenario

UK CLIMATE PROJECTIONS

Plot Details:

Data Source: Probabilistic Land	Temporal Average: DJF
Future Climate Change: True	Spatial Average: Region
Variables: precip_dmean_tmean_perc	Location: South East England
Emissions Scenario: Medium	Probability Data Type: cdf
Time Period: 2010–2039, ..., 2070–2099	

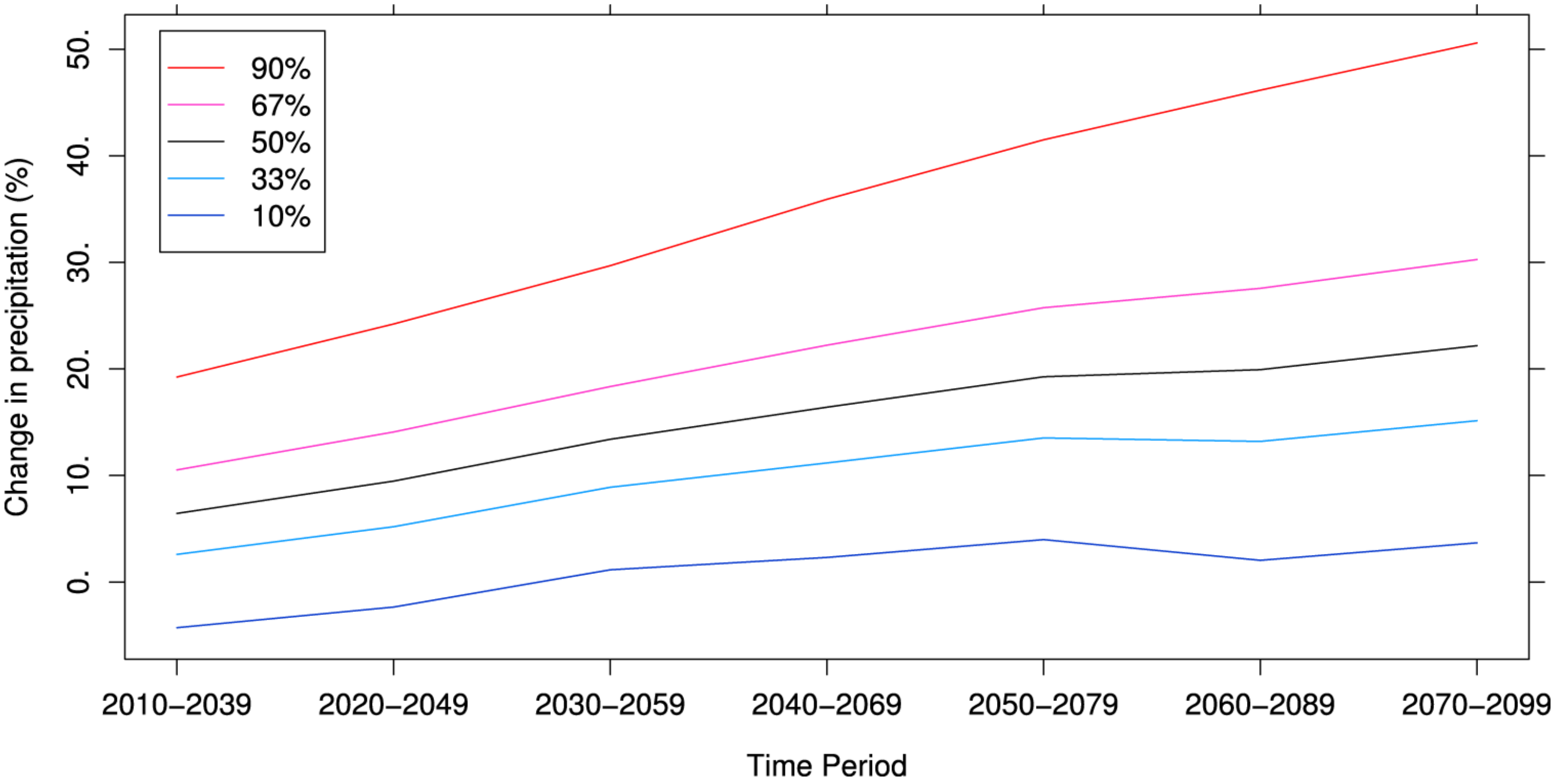

FIGURE 5 – Change in Winter Precipitation – Medium Emissions Scenario

Plot Details:

Data Source: Probabilistic Land	Temporal Average: DJF
Future Climate Change: True	Spatial Average: Region
Variables: precip_dmean_tmean_perc	Location: South East England
Emissions Scenario: High	Probability Data Type: cdf
Time Period: 2010–2039, ..., 2070–2099	

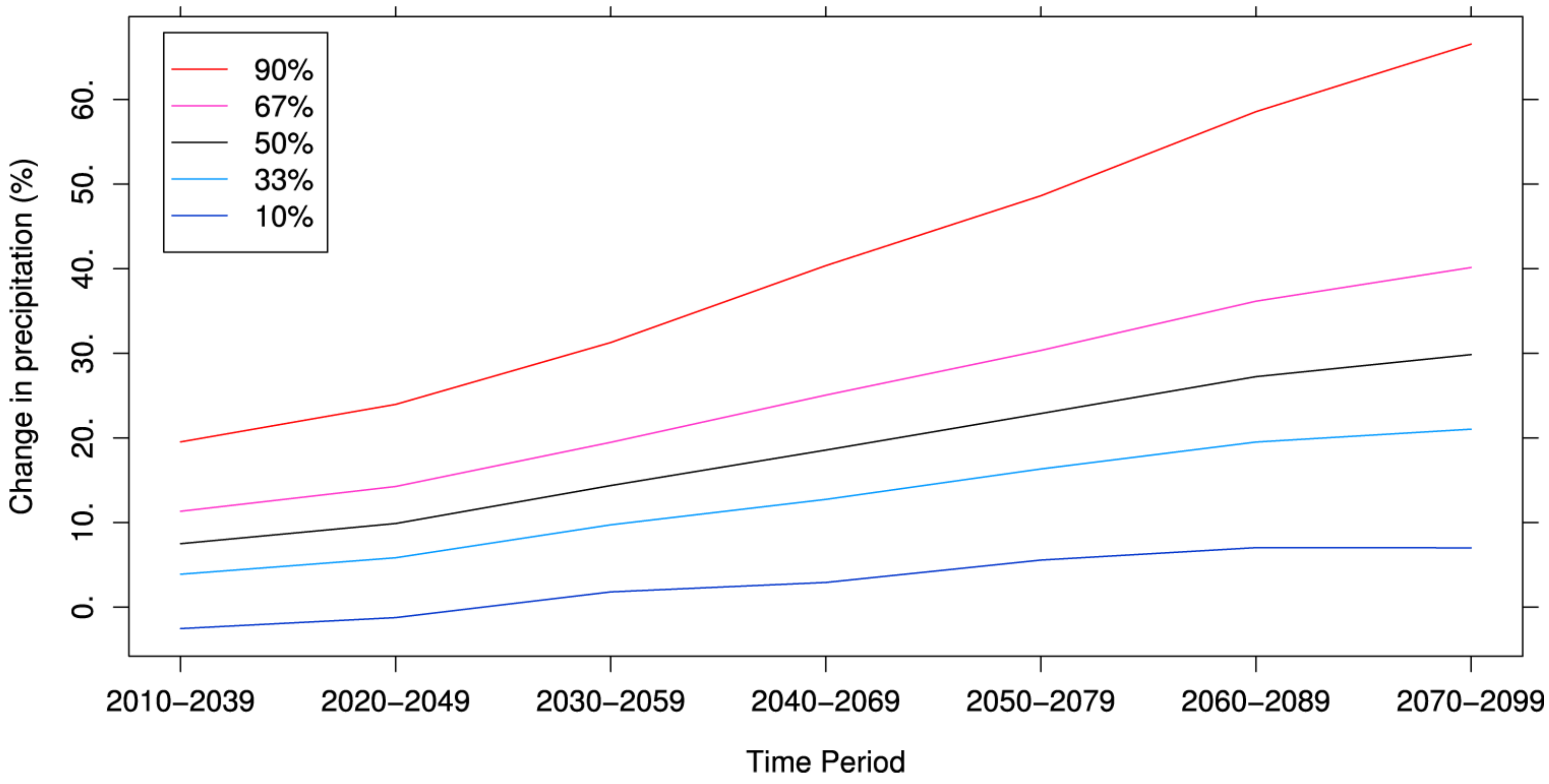

FIGURE 6 – Change in Winter Precipitation – High Emissions Scenario

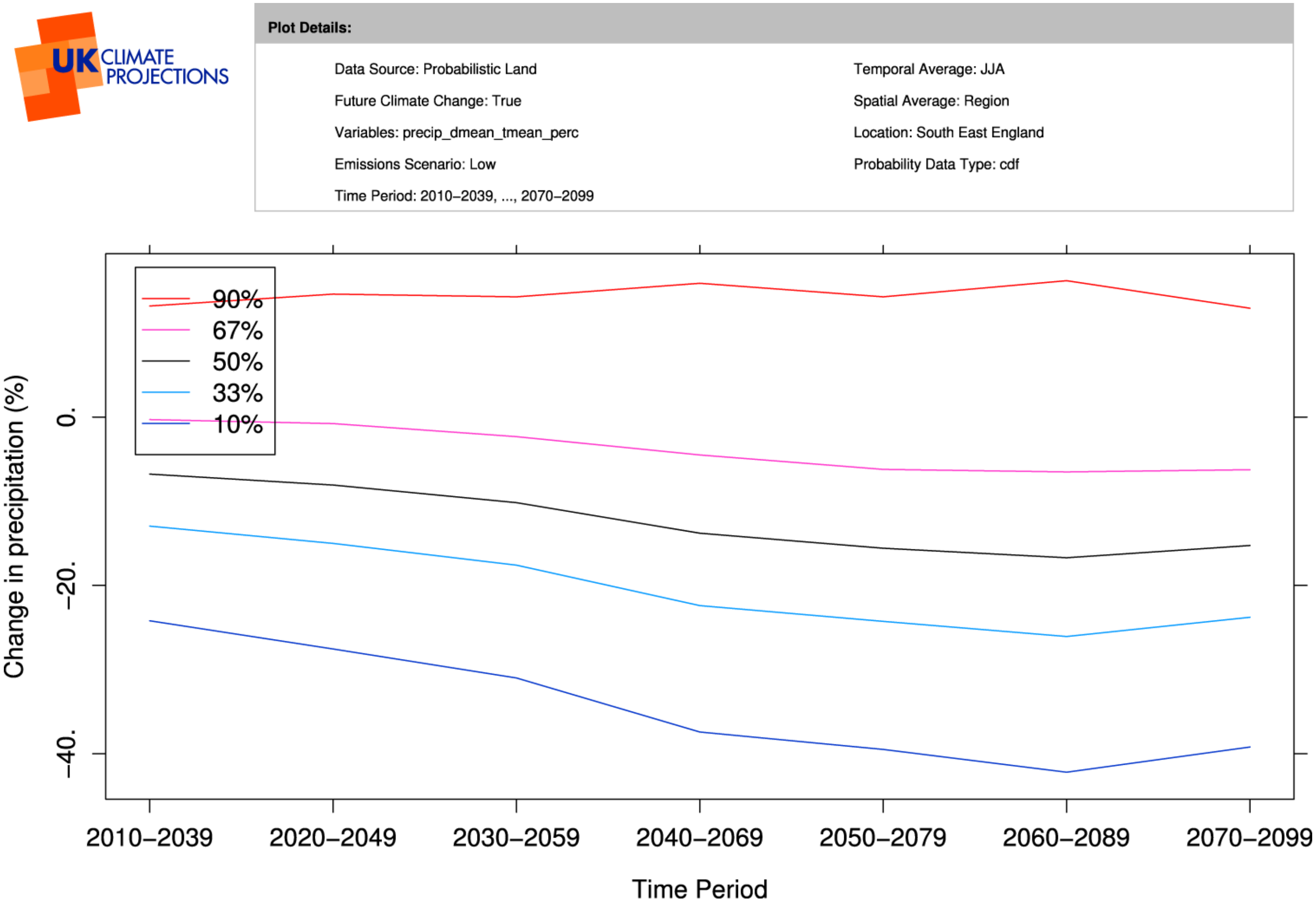

FIGURE 7 – Change in Summer Precipitation – Low Emissions Scenario

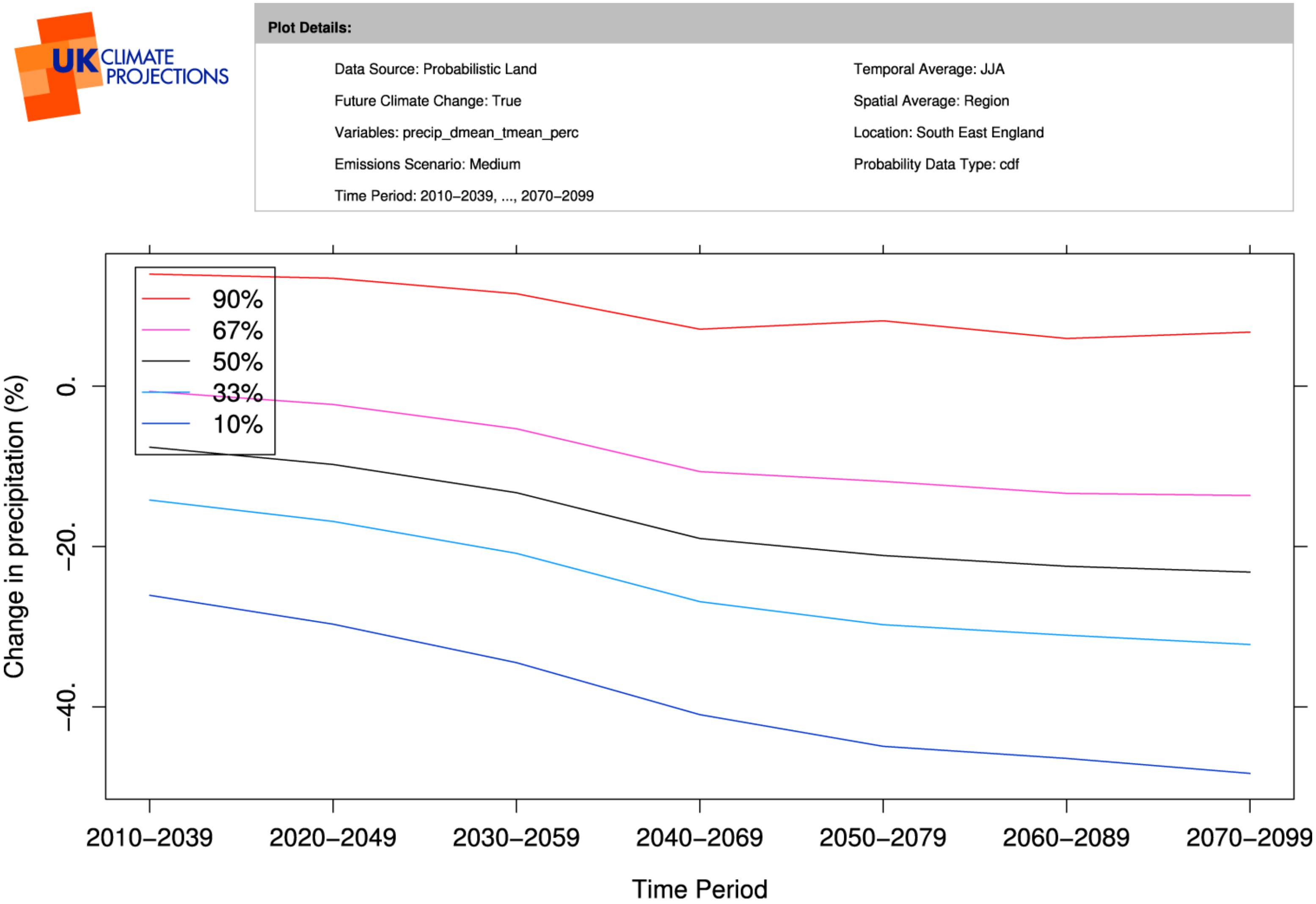

FIGURE 8 – Change in Summer Precipitation – Medium Emissions Scenario

UK CLIMATE PROJECTIONS

Plot Details:

Data Source: Probabilistic Land	Temporal Average: JJA
Future Climate Change: True	Spatial Average: Region
Variables: precip_dmean_tmean_perc	Location: South East England
Emissions Scenario: High	Probability Data Type: cdf
Time Period: 2010–2039, ..., 2070–2099	

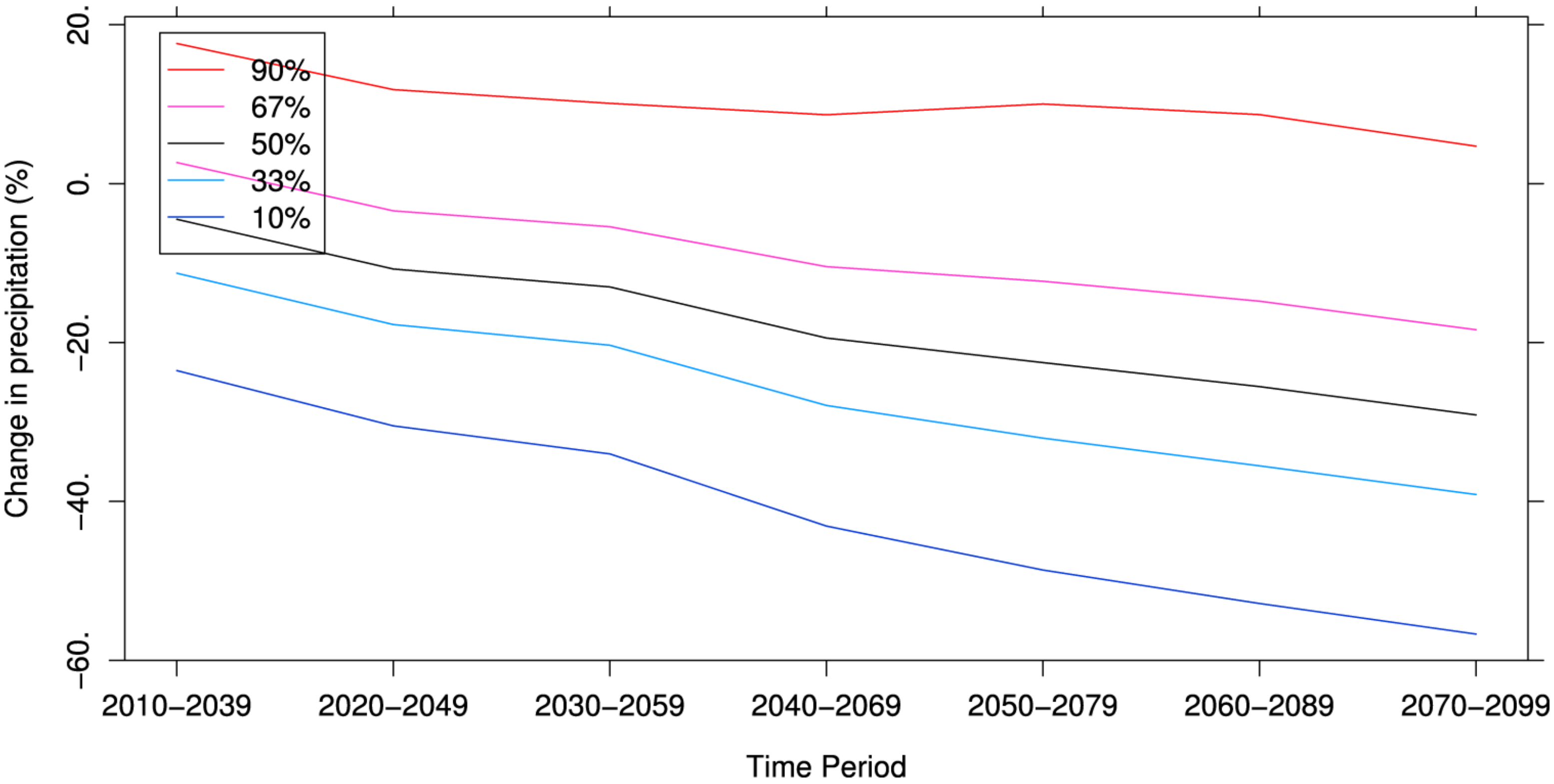

FIGURE 9 – Change in Summer Precipitation – High Emissions Scenario

	London			Cardiff			Edinburgh			Belfast		
	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low
2000	3.5	3	2.5	3.5	2.9	2.5	2.2	1.6	1.2	2.3	1.7	1.3
2010	7.3	6.2	5.3	7.3	6.2	5.3	4.7	3.5	2.6	4.9	3.8	2.8
2020	11.5	9.7	8.2	11.5	9.7	8.2	7.5	5.7	4.3	7.8	6	4.6
2030	16	13.5	11.4	15.9	13.4	11.4	10.7	8.2	6.1	11.1	8.6	6.6
2040	20.8	17.5	14.8	20.8	17.5	14.8	14.2	10.9	8.2	14.7	11.4	8.7
2050	25.8	21.8	18.4	25.9	21.8	18.4	18	13.9	10.5	18.6	14.5	11.1
2060	31.4	26.3	22.2	31.4	26.3	22.2	22.1	17.1	13	22.9	17.8	13.7
2070	37.2	31.2	26.3	37.1	31.1	26.3	26.6	20.6	15.7	27.4	21.4	16.5
2080	43.3	36.3	30.5	43.3	36.2	30.5	31.4	24.4	18.6	32.3	25.3	19.6
2090	49.7	41.6	35	49.7	41.6	35	36.5	28.4	21.8	37.6	29.4	22.8
2095	53.1	44.4	37.3	53.1	44.4	37.3	39.2	30.5	23.4	40.3	31.6	24.5

FIGURE 10 – Central Estimate for Relative Sea-level Change

Appendix 2

Tables of climate change effect, impact and consequence

TABLE 1 - WATER RESOURCES

Climate change effect			
Increased temperature and more extreme variation in temperature	Changes in rainfall patterns		Sea level rise
	Less rainfall or longer dry periods	More rainfall, or more intense rainfall (increased storminess)	
Impact: • Demographic change (resident/tourist population moving from stressed to less stressed areas) • Changes in domestic water use (eg more showers) • Increased garden watering • Increased evapo-transpiration Consequence: • Potential increased demand or reduced supply with consequent stress on water resources	Impact: • Reduction in annual average rainfall • More frequent periods of drought • Seasonal variability leading to less summer rainfall, more winter rainfall • Lower summer river flows • Lower borehole recharge Consequence: • Potential reduced supply with consequent stress on water resources	Impact: • Direct flooding of water supply sites • Loss of power supply Consequence: • Risk of immediate loss of supply for a period of hours or potentially weeks • Potential contamination of water supply	Impact: • Saline intrusion into boreholes • Change in tidal limits of rivers and increased salinity Consequence: • Potential reduced supply with consequent stress on water resource
Impact: • Invasive species in rivers and reservoirs • Increased algal and other biological growth Consequence: • Potential requirement for changes in the storage and treatment of raw water		Impact: • Logistic and transport difficulties • Structural damage Consequence: • Risk to supply for period of hours or days	Impact: • Direct flooding of water supply sites Consequence: • Risk of immediate loss of supply for a period of hours or potentially weeks

TABLE 2 - WATER TREATMENT

Climate change effect			
Increased temperature and more extreme variation in temperature	**Changes in rainfall patterns**		**Sea level rise**
	Less rainfall or longer dry periods	**More rainfall, or more intense rainfall (increased storminess)**	
Impact: • Demographic change (resident/tourist population moving from stressed to less stressed areas) • Changes in domestic water use (eg more showers) • Increased garden watering Consequence: • Potential increased demand with consequent stress on water treatment capacity	Impact: • Changes in domestic water use (eg more showers) • Increased garden watering Consequence: • Potential changes in daily water usage patterns and possible increase in peak demand putting stress on the treatment processes	Impact: • Direct flooding of water treatment sites • Loss of power supply Consequence: • Risk of immediate loss of supply for a period of hours or potentially weeks • Potential contamination of water supply	Impact: • Saline intrusion into boreholes • Change in tidal limits of rivers and increased salinity Consequence: • May affect the level of treatment processes required
Impact: • Increased microbiological action Consequence: • Potential effect on treatment processes; discolouration and odour problems		Impact: • Poor raw water quality during heavy rainfall, particularly from river sources Consequence: • May affect the level of treatment processes required	Impact: • Direct flooding of water treatment sites • Loss of power supply Consequence: • Risk of immediate loss of supply for a period of hours or potentially weeks • Potential contamination of water supply
Impact: • Concern over raw water quality leading to higher potable water standards Consequence: • May affect the level of treatment required		Impact: • Logistic and transport difficulties • Structural damage Consequence: • Risk to supply for period of hours or days	
Impact: • Increased wetting and drying cycles and consequent ground movement Consequence: • Additional investment may be required to protect and maintain structures.			

TABLE 3 - WATER DISTRIBUTION

Climate change effect			
Increased temperature and more extreme variation in temperature	Changes in rainfall patterns		Sea level rise
	Less rainfall or longer dry periods	More rainfall, or more intense rainfall (increased storminess)	
Impact: • Demographic change (resident/tourist population moving from stressed to less stressed areas) • Changes in domestic water use (eg more showers) • Increased garden watering Consequence: • Potential increased peak demand with consequent stress on water distribution capacity	Impact: • Changes in domestic water use (eg more showers) • Increased garden watering Consequence: • Potential changes in daily water usage patterns and possible increase in peak demand putting stress on the distribution system	Impact: • Direct flooding • Loss of power supply Consequence: • Risk of immediate loss of supply for a period of hours or potentially weeks • Potential contamination of water supply	Impact: • Direct flooding • Loss of power supply Consequence: • Risk of immediate loss of supply for a period of hours or potentially weeks • Potential contamination of water supply
Impact: • Increased microbiological action Consequence: • Potential reduction in water quality between treatment process and customer		Impact: • Logistic and transport difficulties • Structural damage Consequence: • Risk to distribution system for period of hours or days	
Impact: • Increased wetting and drying cycles and consequent ground movement Consequence: • Additional investment may be required to protect and maintain pipelines and to manage leakage			

TABLE 4 - WASTEWATER COLLECTION AND SURFACE WATER MANAGEMENT

Climate change effect			
Increased temperature and more extreme variation in temperature	Changes in rainfall patterns		Sea level rise
	Less rainfall or longer dry periods	More rainfall, or more intense rainfall (increased storminess)	
Impact: • Demographic change (resident/tourist population moving from stressed to less stressed areas) • Changes in domestic water use (eg more showers) Consequence: • Potential increased peak demand with consequent stress on wastewater collection capacity	Impact: • Changes in domestic water use (eg more showers) Consequence: • Potential changes in daily water usage patterns and possible increase in peak demand putting stress on the wastewater collection system	Impact: • Direct flooding • Flooding of low lying pumping stations • Loss of power supply Consequence: • Risk of increased flooding of customers' properties (both internal and external), highways and public open space • Risk of immediate failure of collection system for a period of hours or potentially weeks	Impact: • Direct flooding • Flooding of low lying pumping stations • Loss of power supply Consequence: • Risk of increased flooding of customers' properties (both internal and external), highways and public open space • Risk of immediate failure of collection system for a period of hours or potentially weeks
Impact: • Increased microbiological action Consequence: • Risk of increased attack from H2S affecting structural condition of pipelines • Risk of increased odour resulting in customer complaints	Impact: • Longer dry periods Consequence: • Potential for greater deposition of solids and consequent blockage leading to flooding and pollution	Impact: • Higher groundwater table in winter Consequence: • Potential for increased infiltration	Impact: • Increased sea level preventing free discharge of surface water Consequence: • Potential requirement for pumped outfalls at extreme high tide levels
Impact: • Increased wetting and drying cycles and consequent ground movement Consequence: • Additional investment may be required to protect and maintain pipelines and to manage infiltration		Impact: • Logistic and transport difficulties • Structural damage Consequence: • Risk to collection system for period of hours or days	Impact: • Higher groundwater table in winter Consequence: • Potential for increased saline infiltration

TABLE 5 - WASTEWATER TREATMENT

Climate change effect			
Increased temperature and more extreme variation in temperature	**Changes in rainfall patterns**		**Sea level rise**
	Less rainfall or longer dry periods	**More rainfall, or more intense rainfall (increased storminess)**	
Impact: • Demographic change (resident/tourist population moving from stressed to less stressed areas) • Changes in domestic water use (eg more showers) Consequence: • Potential increased demand with consequent stress on wastewater treatment capacity	Impact: • Changes in domestic water use (eg more showers) Consequence: • Potential changes in daily water usage patterns and possible increase in peak demand putting stress on the treatment processes	Impact: • Direct flooding of wastewater treatment sites • Loss of power supply Consequence: • Risk of immediate loss of treatment for a period of hours or potentially weeks • Potential pollution of receiving waters	Impact: • Higher groundwater table in winter Consequence: • Potential for increased saline infiltration and consequent effect on treatment processes
Impact: • Increased microbiological action Consequence: • Potential effect on treatment processes; and poor effluent quality • Potential increased H2S attack on concrete structures	Impact: • Lower river flows during summer Consequence: • Potential requirement for tightened effluent standards	Impact: • Logistic and transport difficulties • Structural damage Consequence: • Risk to treatment processes for period of hours or days	Impact: • Direct flooding of wastewater treatment sites • Loss of power supply Consequence: • Risk of immediate loss of treatment for a period of hours or potentially weeks • Potential pollution of receiving waters
Impact: • Concern over receiving water quality leading to higher effluent standards Consequence: • May affect the level of treatment processes required			
Impact: • Increased wetting and drying cycles and consequent ground movement Consequence: • Additional investment may be required to protect and maintain structures.			

TABLE 6 - SLUDGE TREATMENT AND DISPOSAL

Climate change effect			
Increased temperature and more extreme variation in temperature	**Changes in rainfall patterns**		**Sea level rise**
	Less rainfall or longer dry periods	**More rainfall, or more intense rainfall (increased storminess)**	
Impact: • Greater risk of odour complaints (onsite and when applied to land) Consequence: • Additional investment may be required to mitigate impact.	Impact: • May increase the demand for biosolids to improve dry soil Consequence: • Beneficial	Impact: • Increased risk of 'spoiling' sludge stockpiles creating an unusable product and increasing costs to return to a stable cake Consequence: • Additional investment may be required to protect sludge stockpiles	Impact: • None
Impact: • Increased risk of septicity in sludge making sludge difficult to treat Consequence: • Additional investment may be required to treat sludge to required standards		Impact: • Increased summer rainfall may make getting onto the land to spread biosolids more difficult Consequence: • Alternative disposal routes may be required, with consequent increased investment •	
Impact: • Change in crops types grown which may not require biosolids application (eg salad crops, vineyards etc) Consequence: • Alternative disposal routes may be required, with consequent increased investment			

Appendix 3

Risk Matrix

TABLE 7 - WATER RESOURCES							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Severity*	*Immediacy*	*Inertia*	*Barriers*	*Business as usual*
Water Resources	Increase in temperature	Demographic change or increased demand for water	High	Medium	Medium	Medium	Yes
		Invasive species or increased microbial action	Low	Low	Low	Medium	Yes
	Less rainfall	Reduced water resource	High	Medium	Low	Medium	Yes
	Increased storminess	Direct flooding of supply sites	Medium	Medium	Low	Low	Yes
		Loss of power supply	Medium	Medium	Low	Low	Yes
		Logistic and transport difficulties	Low	Low	Low	Low	Yes
	Sea-level rise	Saline intrusion in boreholes, and reduced supply	High (in coastal areas)	Low	Low	Low	Yes
		Direct flooding of supply sites	High (in coastal areas)	Low	Low	Low	Yes

TABLE 8 - WATER TREATMENT							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Severity*	*Immediacy*	*Inertia*	*Barriers*	*Business as usual*
Water Treatment	Increase in temperature	Demographic change or increased demand for water	Medium	Low	Low	Low	Yes
		Increased microbial action	Low	Low	Low	Low	Yes
		Poor raw water quality	Low	Low	Low	Low	Yes
		Increased wetting and drying cycles and consequent ground movement	Low	Low	Low	Low	Yes
	Less rainfall	Increased water usage (eg garden watering)	Medium	Low	Low	Low	Yes
	Increased storminess	Direct flooding of treatment sites	Medium	Medium	Low	Low	Yes
		Loss of power supply	Medium	Medium	Low	Low	Yes
		Logistic and transport difficulties	Low	Low	Low	Low	Yes
	Sea-level rise	Saline intrusion in boreholes, and poor raw water quality	High (in coastal areas)	Low	Medium	Medium	Yes
		Direct flooding of treatment sites	High (in coastal areas)	Low	Medium	Medium	Yes

TABLE 9 - WATER DISTRIBUTION							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Severity*	*Immediacy*	*Inertia*	*Barriers*	*Business as usual*
Water Distribution	Increase in temperature	Demographic change or increased demand for water	Medium	Low	Low	Low	Yes
		Increased microbial action	Low	Low	Low	Low	Yes
		Increased wetting and drying cycles, and consequent ground movement	Medium	Low	Low	Low	Yes
	Less rainfall	Increased water usage (eg garden watering)	Medium	Low	Low	Low	Yes
	Increased storminess	Direct flooding	Low	Low	Low	Low	Yes
		Loss of power supply	Medium	Medium	Low	Low	Yes
		Logistic and transport difficulties	Low	Low	Low	Low	Yes
	Sea-level rise	Direct flooding	Low	Low	Low	Low	Yes

TABLE 10 - WASTEWATER COLLECTION AND SURFACE WATER MANAGEMENT							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Severity*	*Immediacy*	*Inertia*	*Barriers*	*Business as usual*
Wastewater collection and surface water management	Increase in temperature	Demographic change or increased demand for water	Low	Low	Low	Low	Yes
		Increased microbial action and consequent increase from H2S attack	Medium	Low	Low	Low	Yes
		Increased wetting and drying cycles, and consequent ground movement	Low	Low	Low	Low	Yes
	Less rainfall	Increased water usage	Low	Low	Low	Low	Yes
		Longer dry periods and potential for increased blockage rates in sewers	Medium	Low	Low	Low	Yes
	Increased storminess	Direct flooding of property and company assets	High	High	Medium	Medium	Yes
		Loss of power supply	Medium	Medium	Low	Low	Yes
		Logistic and transport difficulties	Medium	Medium	Low	Low	Yes
	Sea-level rise	Direct flooding of property and company assets	High (in coastal areas)	Low	Medium	Medium	Yes
		Increased sea level preventing free discharge of surface water	High (in coastal areas)	Low	Medium	Medium	Yes
		Higher groundwater table	High (in coastal areas)	Low	Medium	Medium	Yes

TABLE 11 - WASTEWATER TREATMENT							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Severity*	*Immediacy*	*Inertia*	*Barriers*	*Business as usual*
Wastewater Treatment	Increase in temperature	Demographic change or increased usage of water	Low	Low	Low	Low	Yes
		Increased microbial action	Low	Low	Low	Low	Yes
		Potential increased impact on receiving water (lower river flows)	Medium	Low	Low	Medium	Yes
		Increased wetting and drying cycles and consequent ground movement	Low	Low	Low	Low	Yes
	Less rainfall	Increased water usage	Low	Low	Low	Low	Yes
	Increased storminess	Direct flooding of treatment sites	Medium	Medium	Low	Low	Yes
		Loss of power supply	Medium	Medium	Low	Low	Yes
		Logistic and transport difficulties	Low	Low	Low	Low	Yes
	Sea-level rise	Higher groundwater table, potential increase in saline intrusion	High (in coastal areas)	Low	Medium	Medium	Yes
		Direct flooding of treatment sites	High (in coastal areas)	Low	Medium	Medium	Yes

TABLE 12 – SLUDGE RECYCLING							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Severity*	*Immediacy*	*Inertia*	*Barriers*	*Business as usual*
Sludge Recycling	Increase in temperature	Increased odour or septicity	Low	Low	Low	Low	Yes
		Change in crop types which may not require biosolids application	Medium	Low	Low	Low	Yes
	Less rainfall	May increase demand for biosolids to improve dry soil	Low	Low	Low	Low	Yes
	Increased storminess	Increased risk of spoilage of sludge stockpiles	Low	Low	Low	Low	Yes
		Logistic and transport difficulties	Low	Low	Low	Low	Yes

Appendix 4

Table 1.6 from Defra Template

TABLE 13 - WATER RESOURCES							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Water Resources	Increase in temperature	Demographic change or increased demand for water	Water resource planning has to be flexible and adaptive to any change (whether resulting from climate change or other causes).	The supply/ demand balance is constantly under review, regardless of climate change impact	Increased action on demand management, and management of resources	Covered by Water Resource Management Plan	Changes in demand for water are continuous as is action to mitigate impact.
		Invasive species or increased microbial action	Unknown	Unknown	Increased costs to deal with issue	Continuous monitoring of water quality	No known timescale – reactive response
	Less rainfall	Reduced water resource	Water resource planning has to be flexible and adaptive to any change (whether resulting from climate change or other causes).	The supply/ demand balance is constantly under review, regardless of climate change impact	Increased action on demand management, and management of resources	Covered by Water Resource Management Plan	Changes in demand for water are continuous as is action

TABLE 13 - WATER RESOURCES (cont'd)							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Water Resources	Increased storminess	Direct flooding of supply sites	Variable depending on site	Increased storminess will cause increased flooding	Temporary loss of supply	Analysis of risk for each site, contingency plans for provision of bottled water	Business as usual to deal with existing threat
		Loss of power supply	Immediate impact	Dependent on third party suppliers	Temporary loss of supply	Analysis of risk for each site, contingency plans for provision of bottled water, on-site generation for high-risk sites.	Business as usual to deal with existing threat
		Logistic and transport difficulties	Variable depending on site	Increased storminess will cause increased flooding	Temporary loss of supply	Analysis of risk for each site, contingency plans for provision of bottled water	Business as usual to deal with existing threat

TABLE 13 - WATER RESOURCES (cont'd)							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Water Resources	Sea-level rise	Saline intrusion in boreholes, and reduced supply	Water resource planning has to be flexible and adaptive to any change (whether resulting from climate change or other causes).	The supply/ demand balance is constantly under review, regardless of climate change impact	Increased action on demand management, and management of resources	Covered by Water Resource Management Plan	Changes in demand for water are continuous as is action
		Direct flooding of supply sites	Variable depending on site	Sea-level rise will cause increased flooding	Temporary loss of supply	Analysis of risk for each site, contingency plans for provision of bottled water	Business as usual to deal with existing threat

TABLE 14 - WATER TREATMENT							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Water Treatment	Increase in temperature	Demographic change or increased demand for water	Water resource planning has to be flexible and adaptive to any change (whether resulting from climate change or other causes).	The supply/ demand balance is constantly under review, regardless of climate change impact	Increased action on demand management, and management of resources	Covered by Water Resource Management Plan	Changes in demand for water are continuous as is action to mitigate impact.
		Increased microbial action	Unknown	Unknown	Increased costs to deal with issue	Continuous monitoring of water quality	No known timescale – reactive response
		Poor raw water quality	Unknown	Unknown	Increased costs to deal with issue	Continuous monitoring of water quality	No known timescale – reactive response
		Increased wetting and drying cycles and consequent ground movement	Unknown	Unknown	Increased costs to deal with issue	Periodic review of structural condition of assets	No known timescale – reactive response

TABLE 14 - WATER TREATMENT (cont'd)							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Water Treatment	Less rainfall	Increased water usage (eg garden watering)	Water resource planning has to be flexible and adaptive to any change (whether resulting from climate change or other causes).	The supply/ demand balance is constantly under review, regardless of climate change impact	Increased action on demand management, and management of resources	Covered by Water Resource Management Plan	Changes in demand for water are continuous as is action
	Increased storminess	Direct flooding of treatment sites	Variable depending on site	Increased storminess will cause increased flooding	Temporary loss of supply	Analysis of risk for each site, contingency plans for provision of bottled water	Business as usual to deal with existing threat
		Loss of power supply	Immediate impact	Dependent on third party suppliers	Temporary loss of supply	Analysis of risk for each site, contingency plans bottled water, on-site generation for high-risk sites.	Business as usual to deal with existing threat
		Logistic and transport difficulties	Variable depending on site	Increased storminess will cause increased flooding	Temporary loss of supply	Analysis of risk for each site, contingency plans for provision of bottled water	Business as usual to deal with existing threat

TABLE 14 - WATER TREATMENT (cont'd)							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Water Treatment	Sea-level rise	Saline intrusion in boreholes, and poor raw water quality	Variable depending on site	Sea-level rise will cause increased saline intrusion	Increased costs to deal with issue (additional treatment requirements or alternative supplies.	Continuous monitoring of water quality (business as usual)	Dependent on rate of sea level rise
		Direct flooding of treatment sites	Variable depending on site	Sea-level rise will cause increased flooding	Temporary loss of supply	Analysis of risk for each site, contingency plans for provision of bottled water	Business as usual to deal with existing threat

TABLE 15 - WATER DISTRIBUTION							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Water Distribution	Increase in temperature	Demographic change or increased demand for water	Water distribution networks have to be flexible and adaptive to any change (whether resulting from climate change or other causes).	The impact of demand on the network is constantly under review, regardless of climate change impact	Increased action on demand management, and management of the network	Progressive improvements to the network to mitigate the impact of higher water usage, and consequent lower pressure	Changes in demand for water are continuous as is action to mitigate impact.
		Increased microbial action	Unknown	Unknown	Increased costs to deal with issue	Continuous monitoring of water quality	No known timescale – reactive response
		Increased wetting and drying cycles, and consequent ground movement	Unknown	Unknown	Increased leakage and increased costs to deal with issue	Continuous monitoring of leakage	Leakage from the network is continuously monitored as is action to mitigate impact.
	Less rainfall	Increased water usage (eg garden watering)	Water distribution networks have to be flexible and adaptive to any change (whether climate change or other causes).	The impact of demand on the network is constantly under review, regardless of climate change impact	Increased action on demand management, and management of the network	Progressive improvements to the network to mitigate the impact of higher water usage, and consequent lower pressure	Changes in demand for water are continuous as is action to mitigate impact.

TABLE 15 - WATER DISTRIBUTION (cont'd)							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Water Distribution	Increased storminess	Direct flooding	Variable depending on site	Increased storminess will cause increased flooding	Temporary loss of supply	Analysis of risk for each site, contingency plans for provision of bottled water	Business as usual to deal with existing threat
		Loss of power supply	Immediate impact	Dependent on third party suppliers	Temporary loss of supply	Analysis of risk for each site, contingency plans for provision of bottled water, on-site generation for high-risk sites.	Business as usual to deal with existing threat
		Logistic and transport difficulties	Variable depending on site	Increased storminess will cause increased flooding	Temporary loss of supply	Analysis of risk for each site, contingency plans for provision of bottled water	Business as usual to deal with existing threat
	Sea-level rise	Direct flooding	Variable depending on site	Sea-level rise will cause increased flooding	Temporary loss of supply	Analysis of risk for each site, contingency plans for provision of bottled water	Business as usual to deal with existing threat

TABLE 16 - WASTEWATER COLLECTION AND SURFACE WATER MANAGEMENT							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Wastewater collection and surface water management	Increase in temperature	Demographic change or increased demand for water	Drainage area planning has to be flexible and adaptive to any change (whether resulting from climate change or other causes).	Flood risk is constantly under review, regardless of climate change impact	Flood alleviation and mitigation schemes	Covered by Drainage Area Plans	Flood alleviation schemes are under continuous review, and are primarily dealt with through the Periodic Price Review process
		Increased microbial action and consequent increase from H2S attack	Unknown	Unknown	Increased costs to deal with issue	Continuous monitoring of water quality (business as usual)	No known timescale – reactive response
		Increased wetting and drying cycles, and consequent ground movement	Unknown	Unknown	Increased infiltration and structural failure and increased costs to deal with issue	Periodic monitoring of at-risk sites	Structural condition of sewers is under continuous review, and are primarily dealt with through the Periodic Price Review process

TABLE 16 - WASTEWATER COLLECTION AND SURFACE WATER MANAGEMENT (cont'd)							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Wastewater collection and surface water management	Less rainfall	Increased water usage	Drainage area planning has to be flexible and adaptive to any change (whether resulting from climate change or other causes).	Flood risk is constantly under review, regardless of climate change impact	Flood alleviation and mitigation schemes	Covered by Drainage Area Plans	Flood alleviation schemes are under continuous review, and are primarily dealt with through the Periodic Price Review process
		Longer dry periods and potential for increased blockage rates in sewers	Unknown	Unknown	Increased costs of blockage clearance	Blockages are dealt with immediately	Reactive response
	Increased storminess	Direct flooding of property and company assets	Variable depending on site	Increased storminess will cause increased flooding	Increased flooding	Covered by Drainage Area Plans	Flood alleviation schemes are under continuous review, and are primarily dealt with through the Periodic Price Review process

TABLE 16 - WASTEWATER COLLECTION AND SURFACE WATER MANAGEMENT (cont'd)							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Wastewater collection and surface water management	Increased storminess	Loss of power supply	Immediate impact	Dependent on third party suppliers	Temporary loss of collection system	Analysis of risk for each site, contingency plans for dealing with flooding, on-site generation for high-risk sites.	Business as usual to deal with existing threat
		Logistic and transport difficulties	Variable depending on site	Increased storminess will cause increased flooding	Temporary loss of collection system	Analysis of risk for each site, contingency plans for dealing with flooding, on-site generation for high-risk sites.	Business as usual to deal with existing threat
	Sea-level rise	Direct flooding of property and company assets	Variable depending on site	Sea-level rise will cause increased flooding	Increased flooding	Covered by Drainage Area Plans	Flood alleviation schemes are under continuous review, and are primarily dealt with through the Periodic Price Review process

TABLE 16 - WASTEWATER COLLECTION AND SURFACE WATER MANAGEMENT (cont'd)							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Wastewater collection and surface water management	Sea-level rise	Increased sea level preventing free discharge of surface water	Variable depending on site	Sea-level rise will cause increased flooding	Increased flooding or need for more pumping stations	Covered by Drainage Area Plans	Flood alleviation schemes are under continuous review, and are primarily dealt with through the Periodic Price Review process
		Higher groundwater table	Variable depending on site	Sea-level rise will cause increased flooding	Increased infiltration and increased costs to deal with additional flow	Covered by Drainage Area Plans	Business as usual to deal with existing threat

TABLE 17 - WASTEWATER TREATMENT							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Wastewater Treatment	Increase in temperature	Demographic change or increased usage of water	Wastewater treatment planning has to be flexible and adaptive to any change (whether resulting from climate change or other causes).	The effluent quality from treatment works is constantly under review, regardless of climate change impact	Increased treatment capacity required	Periodic review of available treatment capacity	Requirement for additional capacity addressed through Periodic Price Review process
		Increased microbial action	Unknown	Unknown	Increased costs to deal with issue, or may provide benefits to treatment process	Continuous monitoring of wastewater effluent quality (business as usual)	No known timescale – reactive response
		Potential increased impact on receiving water (lower river flows)	The effluent quality from treatment works is constantly under review, regardless of climate change impact	Potentially tighter discharge standards to protect environment	Environmental permits are the responsibility of the Environment Agency	Requirement for tighter standards addressed through Periodic Price Review process	The effluent quality from treatment works is constantly under review, regardless of climate change impact

TABLE 17 - WASTEWATER TREATMENT (cont'd)							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Wastewater Treatment	Increase in temperature	Increased wetting and drying cycles and consequent ground movement	Unknown	Unknown	Increased costs to deal with issue	Periodic review of structural condition of assets	No known timescale – reactive response
	Less rainfall	Increased water usage	Wastewater treatment planning has to be flexible and adaptive to any change (whether resulting from climate change or other causes).	The effluent quality from treatment works is constantly under review, regardless of climate change impact	Increased treatment capacity required	Periodic review of available treatment capacity	Requirement for additional capacity addressed through Periodic Price Review process
	Increased storminess	Direct flooding of treatment sites	Variable depending on site	Increased storminess will cause increased flooding	Temporary loss of treatment facilities	Analysis of risk for each site, contingency plans	Business as usual to deal with existing threat
		Loss of power supply	Immediate impact	Dependent on third party suppliers	Temporary loss of treatment facilities	Analysis of risk for each site, contingency plans, on-site generation for high-risk sites.	Business as usual to deal with existing threat

TABLE 17 - WASTEWATER TREATMENT (cont'd)							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Wastewater Treatment	Increased storminess	Logistic and transport difficulties	Variable depending on site	Increased storminess will cause increased flooding	Temporary loss of treatment facilities	Analysis of risk for each site, contingency plans	Business as usual to deal with existing threat
	Sea-level rise	Higher groundwater table, potential increase in saline intrusion	Variable depending on site	Sea-level rise will cause increased saline intrusion	Increased costs to deal with issue (additional treatment requirements	Continuous monitoring of effluent quality	Dependent on rate of sea level rise
		Direct flooding of treatment sites	Variable depending on site	Increased storminess will cause increased flooding	Temporary loss of treatment facilities	Analysis of risk for each site, contingency plans	Business as usual to deal with existing threat

TABLE 18 – SLUDGE RECYCLING							
Business function	*Climate variable (e.g. increase in temperature)*	*Primary impact of climate variable (e.g. health)*	*Threshold(s) above which this will affect your organisation*	*Likelihood of threshold(s) being exceeded in the future and confidence in the assessment*	*Potential impacts on organisation and stakeholders*	*Proposed action to mitigate impact*	*Timescale over which risks are expected to materialise and action is planned*
Sludge Recycling	Increase in temperature	Increased odour or septicity	Unknown	Unknown	Increased costs to deal with issue	Monitoring of complaints	No known timescale – reactive response
		Change in crop types which may not require biosolids application	Unknown	Unknown	Increased costs to deal with issue	Periodic review of options for sludge recycling	No known timescale – reactive response
	Less rainfall	May increase demand for biosolids to improve dry soil	Unknown	Unknown	Beneficial impact on recycling options	Periodic review of options for sludge recycling	No known timescale – reactive response
	Increased storminess	Increased risk of spoilage of sludge stockpiles	Variable depending on site	Unknown	Increased costs to deal with issue	Periodic review of options for sludge storage	No known timescale – reactive response
		Logistic and transport difficulties	Variable depending on site	Increased storminess will cause increased flooding	Increased costs to deal with issue	Periodic review of options for sludge recycling	No known timescale – reactive response